Life Cycle Assessment Of Organic Diversion Alternatives And Economic Analysis For Greenhouse Gas Reduction Options

Details of the Life Cycle Energy and GHG Factors Methodologies and Results

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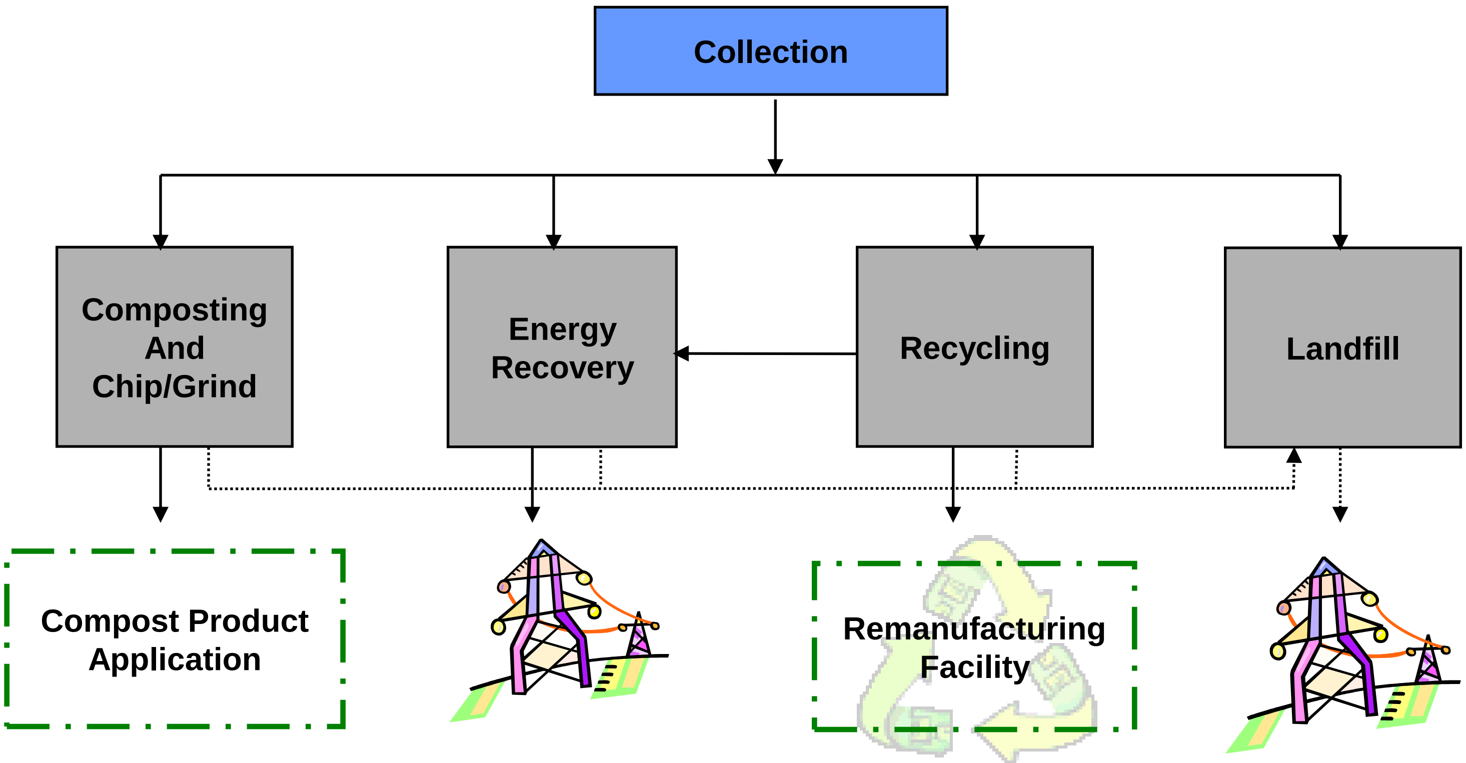
Life Cycle for Waste Management Systems



LCA Parameters Tracked

- Energy consumption/production
- GHG emissions:
  - CO_2 biogenic: results from the biodegradation or combustion of organic material,
  - CO_2 fossil: results from the combustion of fossil-fuel based products,
  - CH_4: results primarily from the anaerobic decomposition of organic material,
  - N_2O: results from the combustion of fossil-fuel based products,
- Carbon sequestration/storage

Process Boundaries

Anaerobic Digestion Process Boundaries

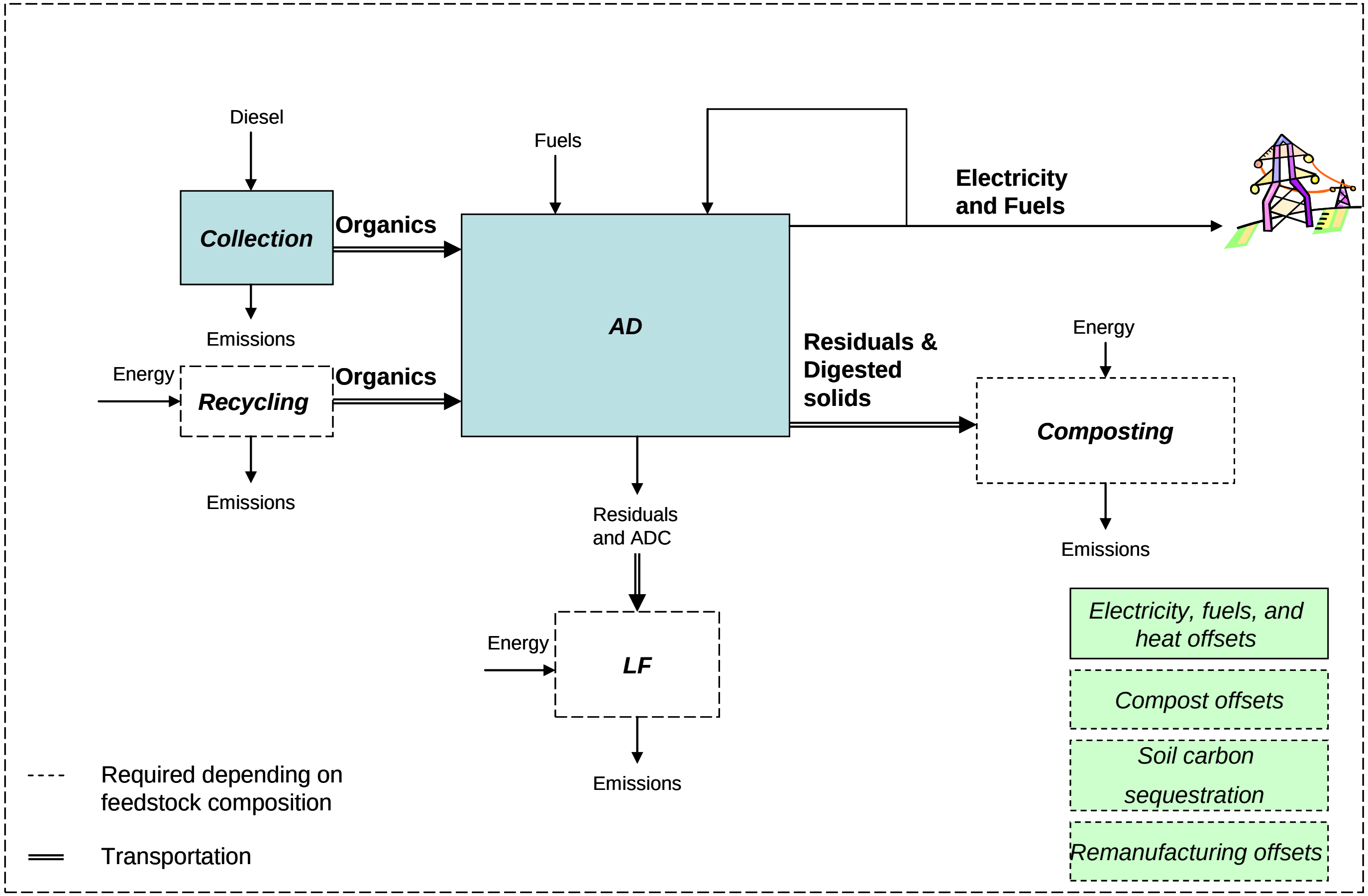


Figure 2-5. AD System Boundaries.

Anaerobic Digestion Process Boundaries

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Figure 2-5. AD System Boundaries

As illustrated in Figure 2-5, the AD process boundaries include all activities from the collection and transportation of organics to the AD facility, the AD process itself, transportation and application of compost product, and transportation and management of residuals. Depending on the feedstock composition, there may be a need to preprocess the incoming waste to remove undesirable materials. The cost and environmental burdens/beneficial offsets associated with recycling were accounted for as will the management of any residuals.

AD system GHG emissions included in the LCA account for the following sources:

Fossil-based CO2 emissions from (1) fuel consumed in the collection and transportation of the organic materials to the AD facility, (2) transportation and application of compost to the application site(s), and (3) transportation and management of residuals. Similarly, any N2O emissions associated with those activities were accounted for.

BTE Process Boundaries

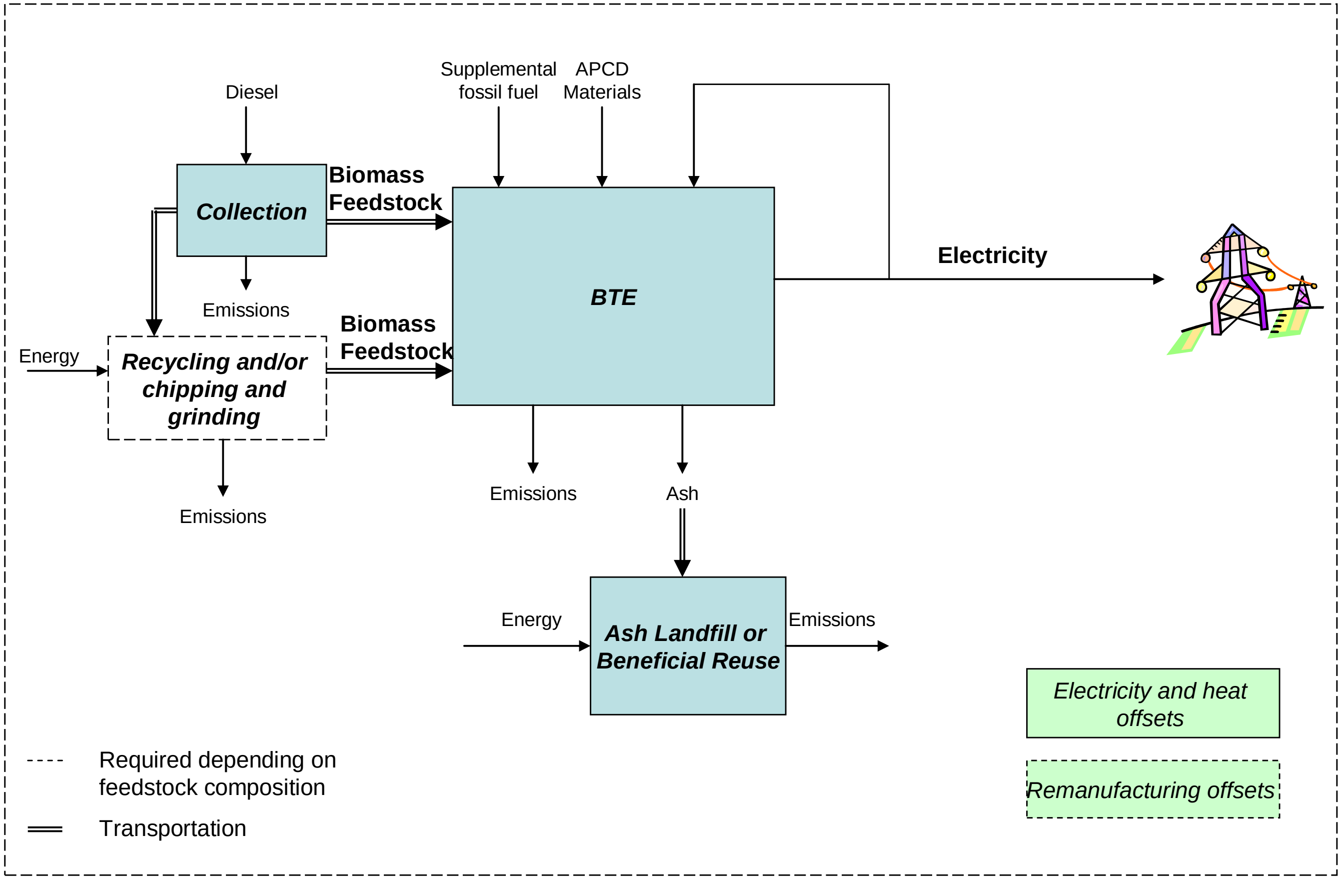

Figure 2-6. BTE System Boundaries.

BTE Process Boundaries

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Figure 2-6. BTE System Boundaries

As illustrated in Figure 2-6, the BTE process boundaries include all activities from the collection and transportation of organics to the BTE facility, the BTE process itself, and transportation and management of residuals. Depending on the feedstock composition, there may be a need to preprocess the incoming waste to remove undesirable materials.

BTE system GHG emissions included in the LCA account for the following sources: Fossil-based CO2 emissions from (1) fuel consumed in the collection and transportation of the biomass feedstock to the BTE facility, (2) the BTE process when using supplemental fossil fuels5 and other associated processes (e.g., production of supplemental fuels and Air Pollution Control [APC] materials), and (3) transportation and management of residuals. Similarly, any N2O emissions associated with those activities were accounted for.

Chipping and Grinding Process Boundaries

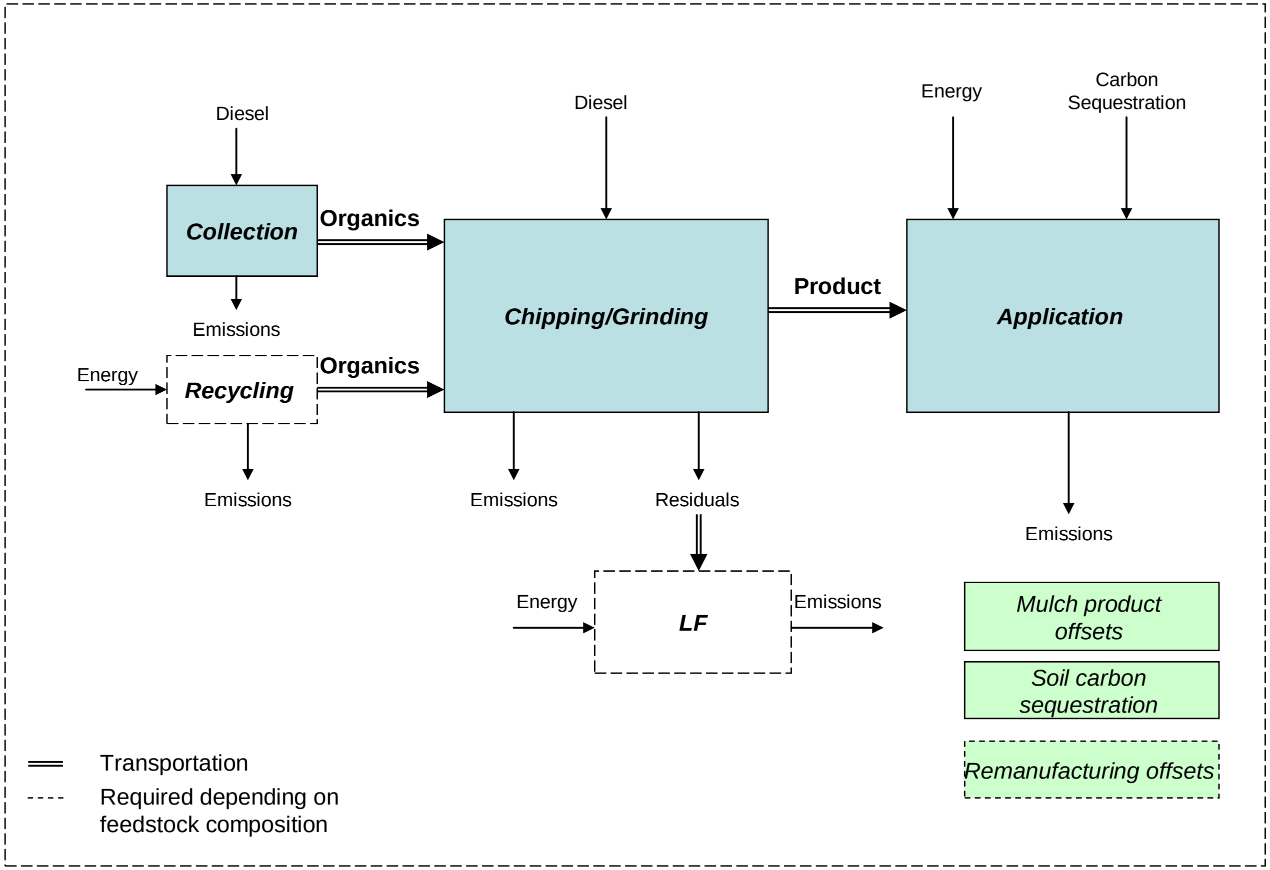

Figure 2-3. Chipping and Grinding System Boundaries.

Chipping and Grinding Process Boundaries

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Figure 2-3. Chipping and Grinding System Boundaries

As illustrated in Figure 2-3, the chipping and grinding process boundaries include all activities from the collection and transportation of organics to the chipping and grinding facility, the chipping and grinding process itself, transportation and application of product, and transportation and management of residuals. Depending on the feedstock composition, there may be a need to preprocess the incoming waste to remove undesirable materials.

Chipping and grinding system GHG emissions included in the LCA account for the following sources:

Fossil-based CO2 emissions from (1) fuel consumed in the collection and transportation of the organic materials to the chipping and grinding facility, (2) operation of the chipping and grinding facility, (3) transportation and application of mulch to the application site(s), and (4) transportation and management of residuals. Similarly, any N2O emissions associated with those activities were accounted for.

Compost Process Boundaries

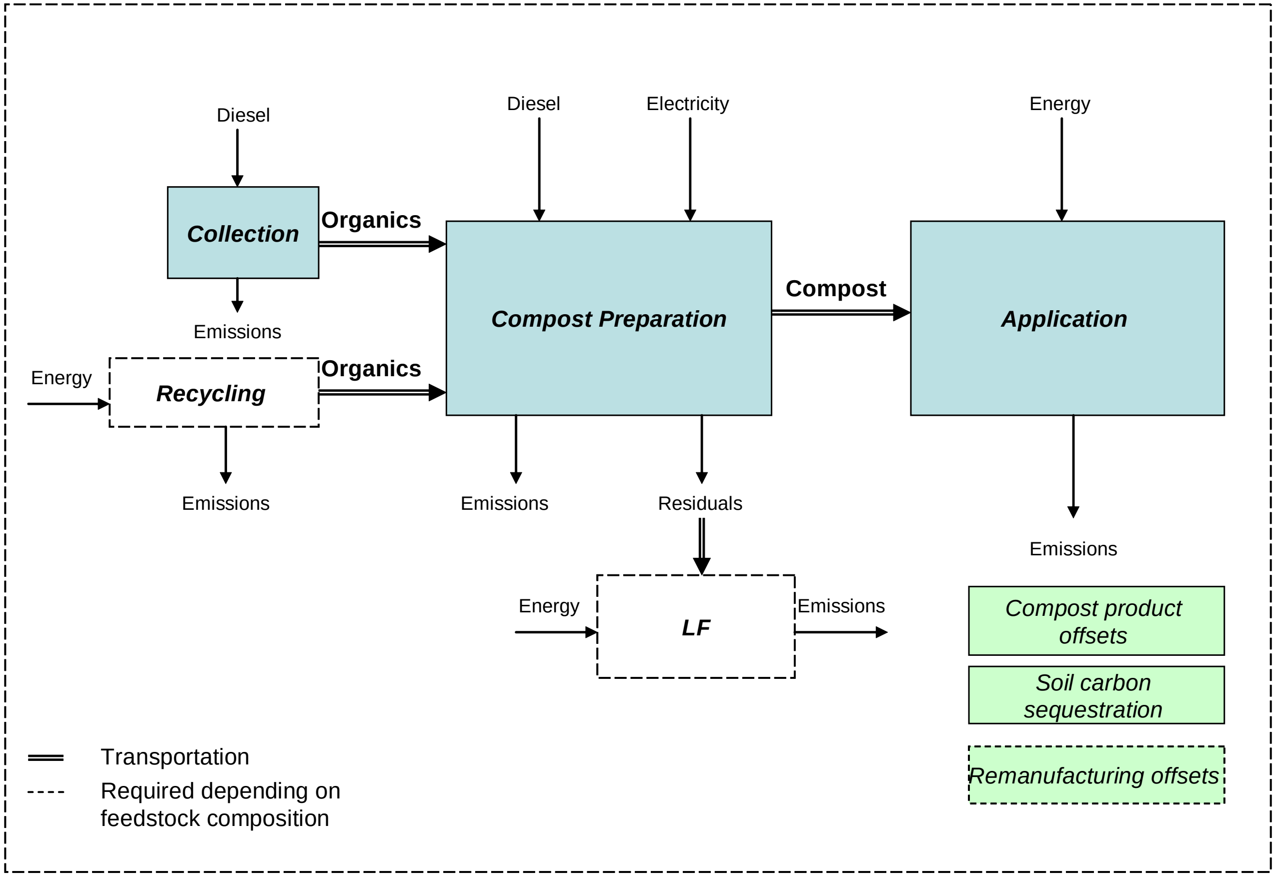

Figure 2-2. Compost System Boundaries.

Compost Process Boundaries

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Figure 2-2. Compost System Boundaries

As illustrated in Figure 2-2, the compost boundaries include all activities from the collection and transportation of organics to the compost facility, the composting process itself, transportation and application of compost product, and transportation and management of residuals. Depending on the feedstock composition, there may be a need to preprocess the incoming waste to remove undesirable materials.

Compost system GHG emissions included in the LCA account for the following sources: Methane (CH4) emissions from anaerobic decomposition; Nitrous oxide (N2O) emissions from NOx denitrification during the latest composting stages; and Fossil-based CO2 emissions from (1) fuel consumed in the collection and transportation of the organic materials to the compost process facility, (2) operation of the compost facility, and (3) transportation and application of compost to the application site(s), and (4) transportation and management of residuals. Similarly, any N2O emissions associated with those activities were accounted for.

Composting also results in biogenic carbon emissions associated with decomposition, both during the composting process and after the compost is added to the soil. However, only non-biogenic carbon emissions were considered in the estimates of GHG emissions from composting. Biogenic carbon emissions are estimated but given a zero carbon equivalence weighting.

Recycling Process Boundaries

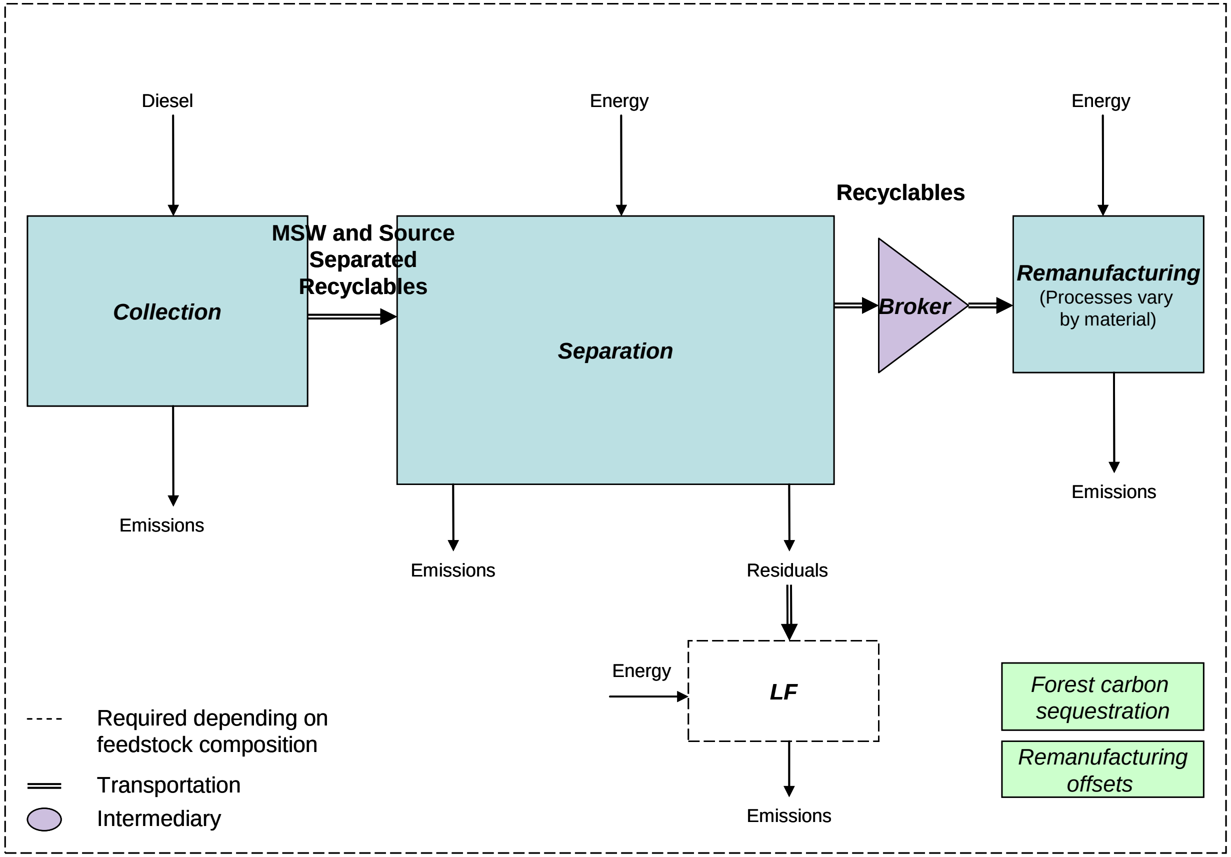

Figure 2-4. Recycling System Boundaries.

Recycling Process Boundaries

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Figure 2-4. Recycling System Boundaries

As illustrated in Figure 2-4, the recycling process boundaries include all activities from the collection and transportation of solid waste, the recycling process itself, transportation to remanufacturing, and transportation and management of residuals.

Recycling system GHG emissions included in the LCA account for the following sources:

Fossil-based CO2 emissions from (1) fuel consumed in the collection and transportation of the solid waste to the MRF facility, (2) operation of the MRF facility, (3) transportation of recyclables to remanufacturing, (4) remanufacturing processes, and (5) transportation and management of residuals. Similarly, any N2O emissions associated with those activities were accounted for.

WTE Process Boundaries

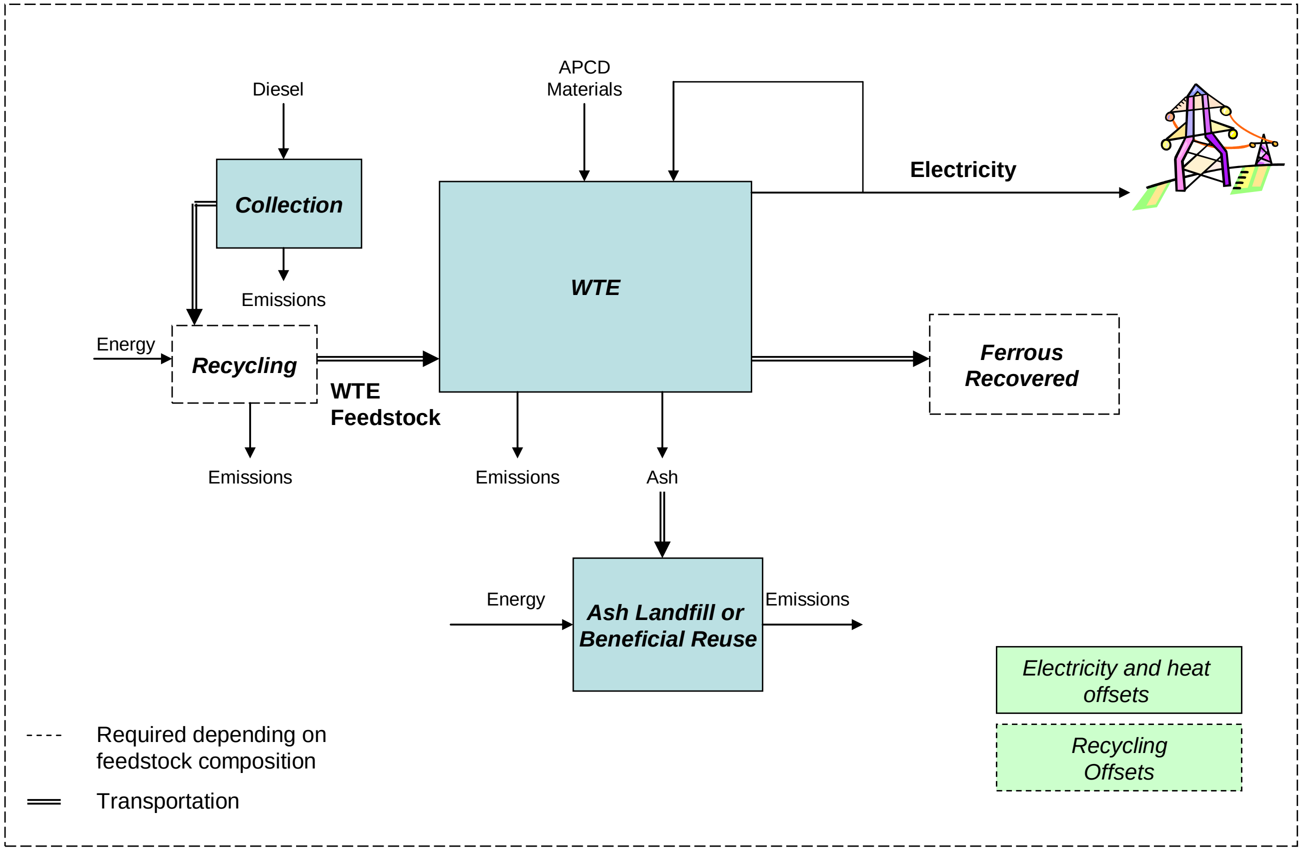

Figure 2-7. WTE System Boundaries.

WTE Process Boundaries

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Figure 2-7. WTE System Boundaries

As illustrated in Figure 2-7, the WTE process boundaries include all activities from the collection and transportation of MSW to the WTE facility, the WTE process itself, and transportation and management of residuals.

WTE system GHG emissions included in the LCA account for the following sources:

Fossil-based CO2 emissions from (1) fuel consumed in the collection and transportation of the MSW to the WTE facility, (2) the WTE process6 and other associated processes (e.g., production of supplemental fuels and Air Pollution Control [APC] materials), and (3) transportation and management of residuals. Similarly, any N2O emissions associated with those activities were accounted for.

Landfill Boundaries

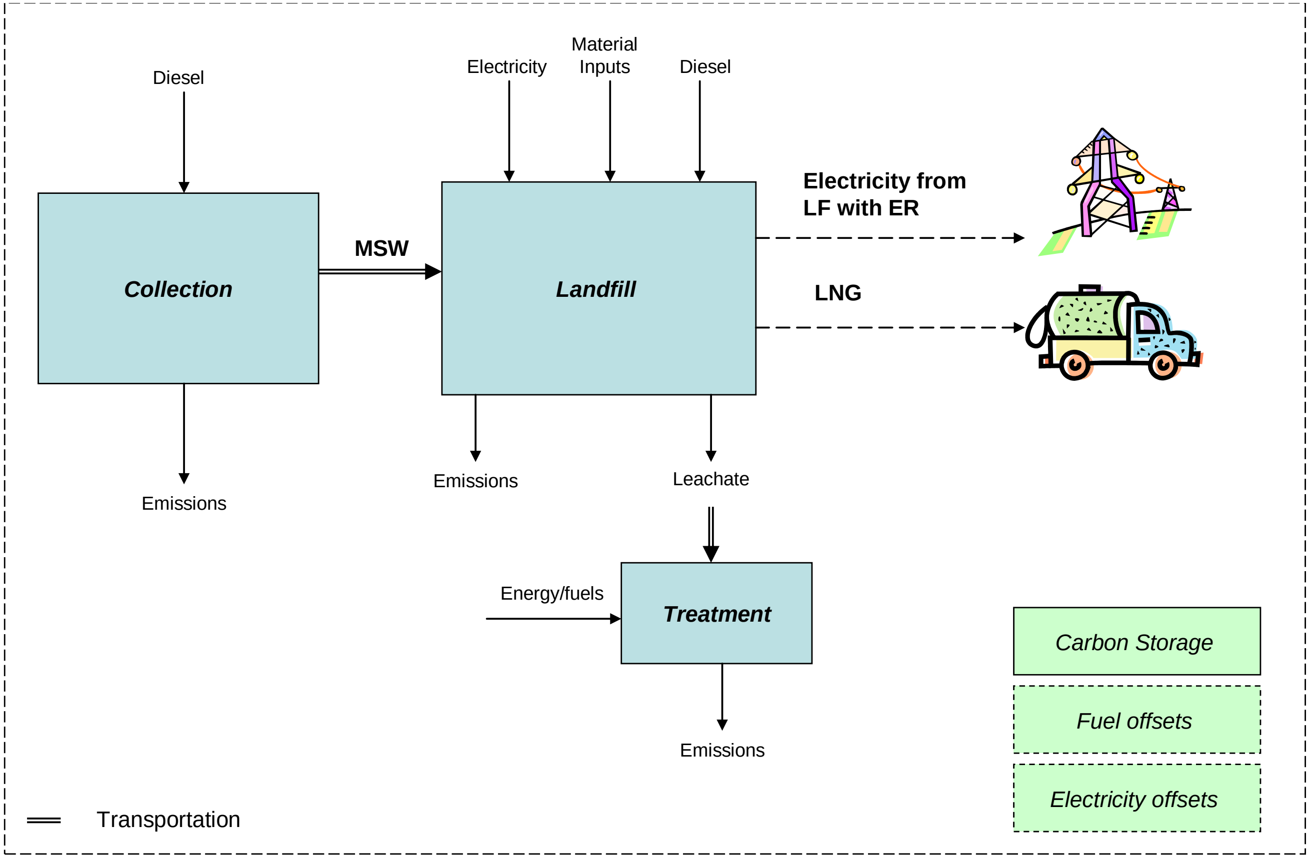

Figure 2-8. Landfill System Boundaries.

Landfill Boundaries

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Figure 2-8. Landfill System Boundaries

As illustrated in **Figure 2-8**, the landfill process boundaries include all activities from the collection and transportation of MSW to the landfill facility, the landfill disposal process itself, and transportation and leachate management.

Landfill system GHG emissions included in the LCA account for the following sources:

CH4 emissions from anaerobic organics decomposition and fossil-based CO2 emissions from (1) fuel consumed in the collection and transportation of the MSW to and within the landfill, (2) production of materials (e.g., materials for liner systems and leachate collection, and (3) leachate transportation to treatment plants outside the landfill range. Similarly, any N2O emissions associated with those activities were accounted for.

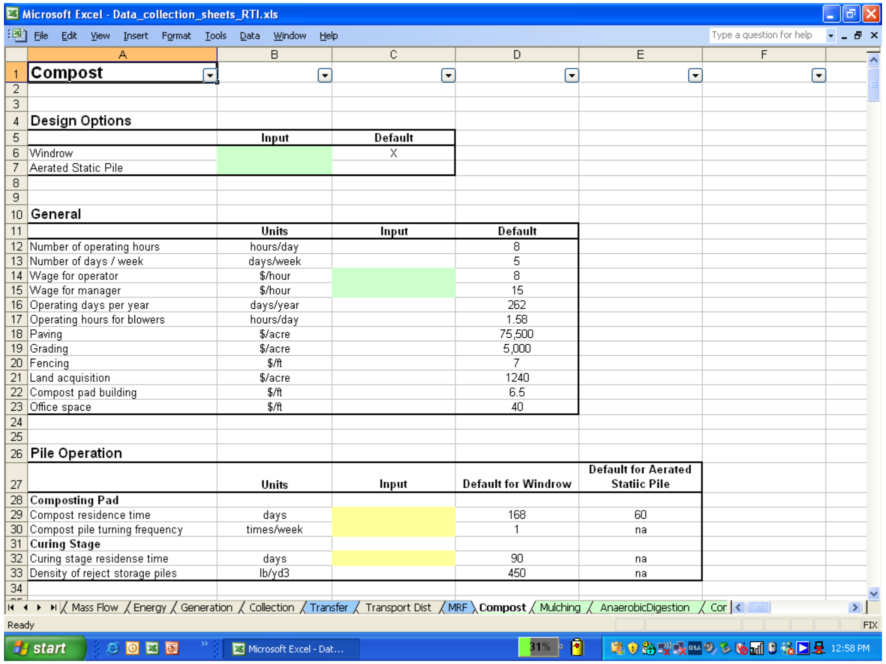
Process Algorithms

Process for Defining LCA Algorithms

- Developed energy use and GHG emission coefficients per the management of a unit (e.g., ton) of waste per each process.
- Identified and reviewed existing, generally accepted methods rather than creating new methods.
  - CA state and region-specific data was used to tailor the coefficients/analysis
- Emphasis on consistency and transparency.

Nature of LCA Data Requested

- Basic facility design and operation
- Materials/process flow
- Energy consumption
- Material inputs
- Efficiency factors
- Emission factors
- Products (energy/materials)
  - Offsets of other products
- Transportation distances


Microsoft Excel - Data_collection_sheets_RTI.xls

	A	B	C	D	E
1	**Compost**				
2					
3					
4	**Design Options**				
5		Input	Default		
6	Windrow		X		
7	Aerated Static Pile				
8					
9					
10	**General**				
11		Units	Input	Default	
12	Number of operating hours	hours/day		8	
13	Number of days / week	days/week		5	
14	Wage for operator	$/hour		8	
15	Wage for manager	$/hour		15	
16	Operating days per year	days/year		262	
17	Operating hours for blowers	hours/day		1.58	
18	Paving	$/acre		75,500	
19	Grading	$/acre		5,000	
20	Fencing	$/ft		7	
21	Land acquisition	$/acre		1240	
22	Compost pad building	$/ft		6.5	
23	Office space	$/ft		40	
24					
25					
26	**Pile Operation**				
27		Units	Input	Default for Windrow	Default for Aerated Static Pile
28	**Composting Pad**				
29	Compost residence time	days		168	60
30	Compost pile turning frequency	times/week		1	na
31	**Curing Stage**				
32	Curing stage residense time	days		90	na
33	Density of reject storage piles	lb/yd3		450	na
34					

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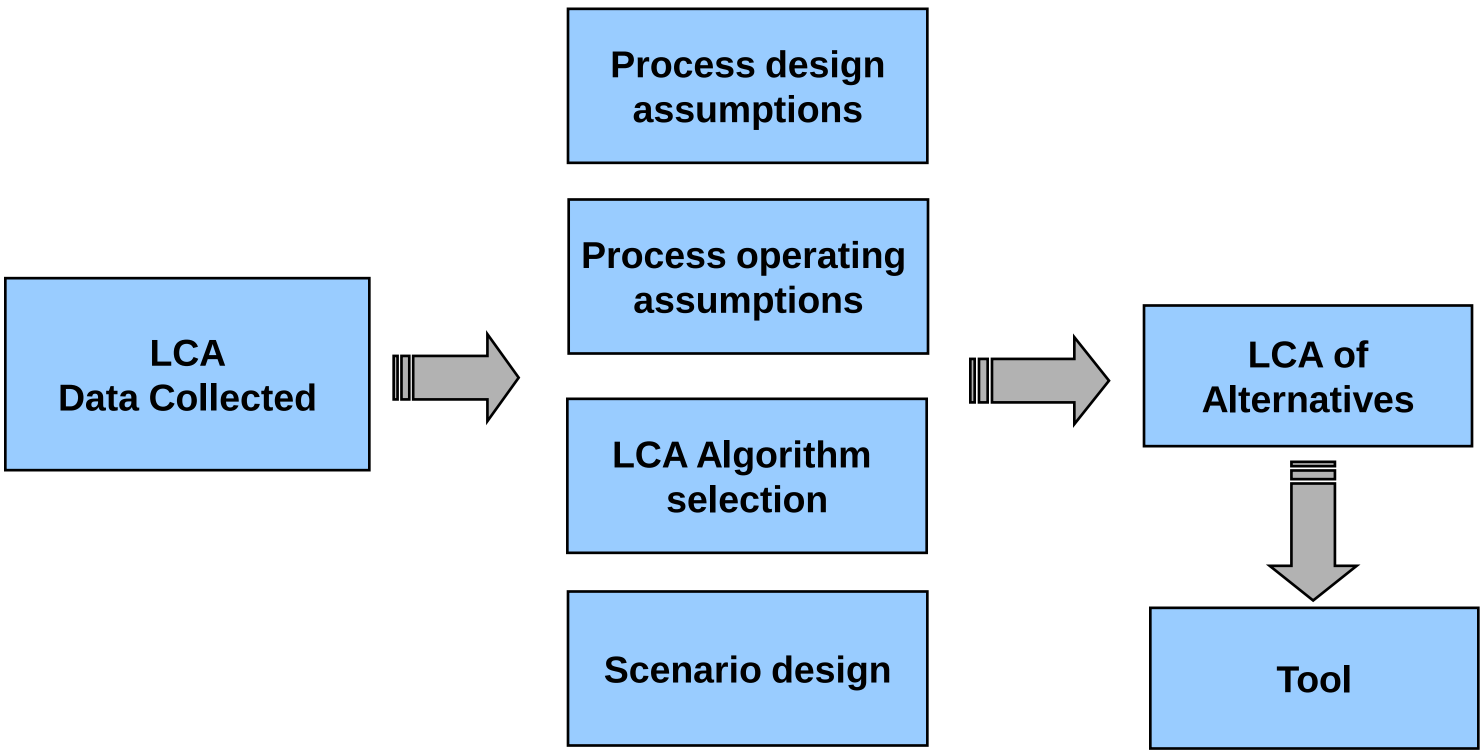
How LCA Data Was Used



How LCA Data Was Used

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Process design assumptions

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Process operating assumptions

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LCA Data Collected → ↓ → LCA of Alternatives

LCA Algorithm selection

↓

Scenario design

Key Regionalization of Assumptions

- **Anaerobic digestion**
  - Residuals to LF as percentage of incoming waste
  - Percentage of total solids
  - Conversion efficiency of waste biological volatile solids
  - Energy recovery efficiency
  - Transportation distance to compost application
  - Transportation distance to residuals disposal
- **Landfill**
  - Gas collection efficiency
  - Total gas yield potential
  - Gas quality (Percent CO2 and CH4)
  - Transportation distance to leachate treatment
- **Recycling**
  - Separation efficiencies
  - Residuals to LF as percentage of incoming waste
  - Electricity requirements
  - Transportation distance to residuals disposal

Example of Net GHG Emission Factors By Process for Newsprint

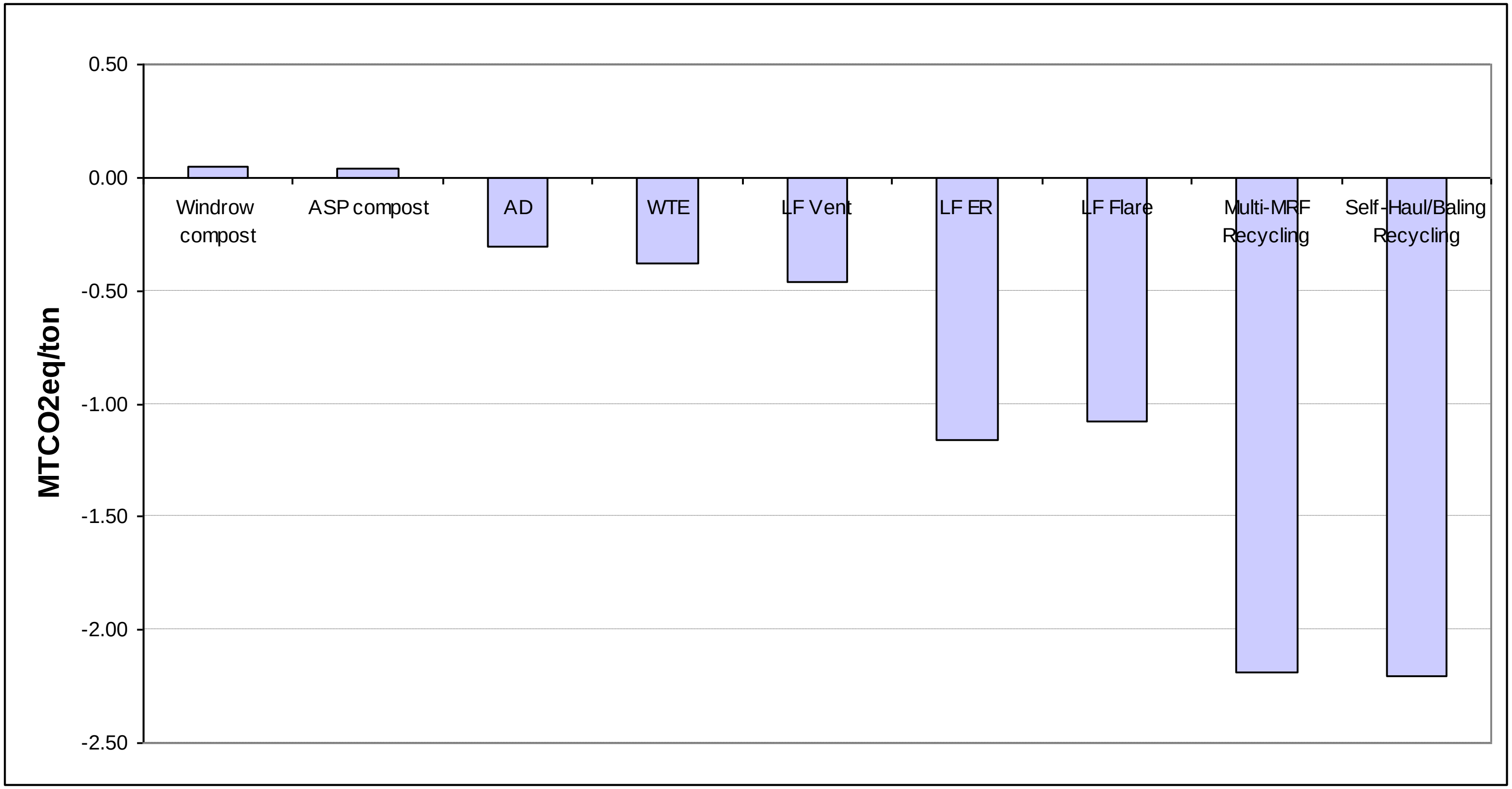

Figure 3-2. Net Per Ton GHG Emission Factors by Management Alternative for Newsprint.

Example of Net GHG Emission Factors By Process for Newsprint

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Example of the GHG emissions and energy consumption factors developed for newsprint.

Figure 3-2 illustrates the net per ton GHG emission factors for newsprint as developed by waste management alternative. The newsprint composting results in positive GHG emission burdens whereas AD, WTE, landfill and recycling alternatives result in net negative GHG emissions (or savings). Note that the chipping and grinding and BTE alternatives were not included because they are not feasible options for newsprint.

Breakdown of GHG Emission Factor for Newsprint Recycling

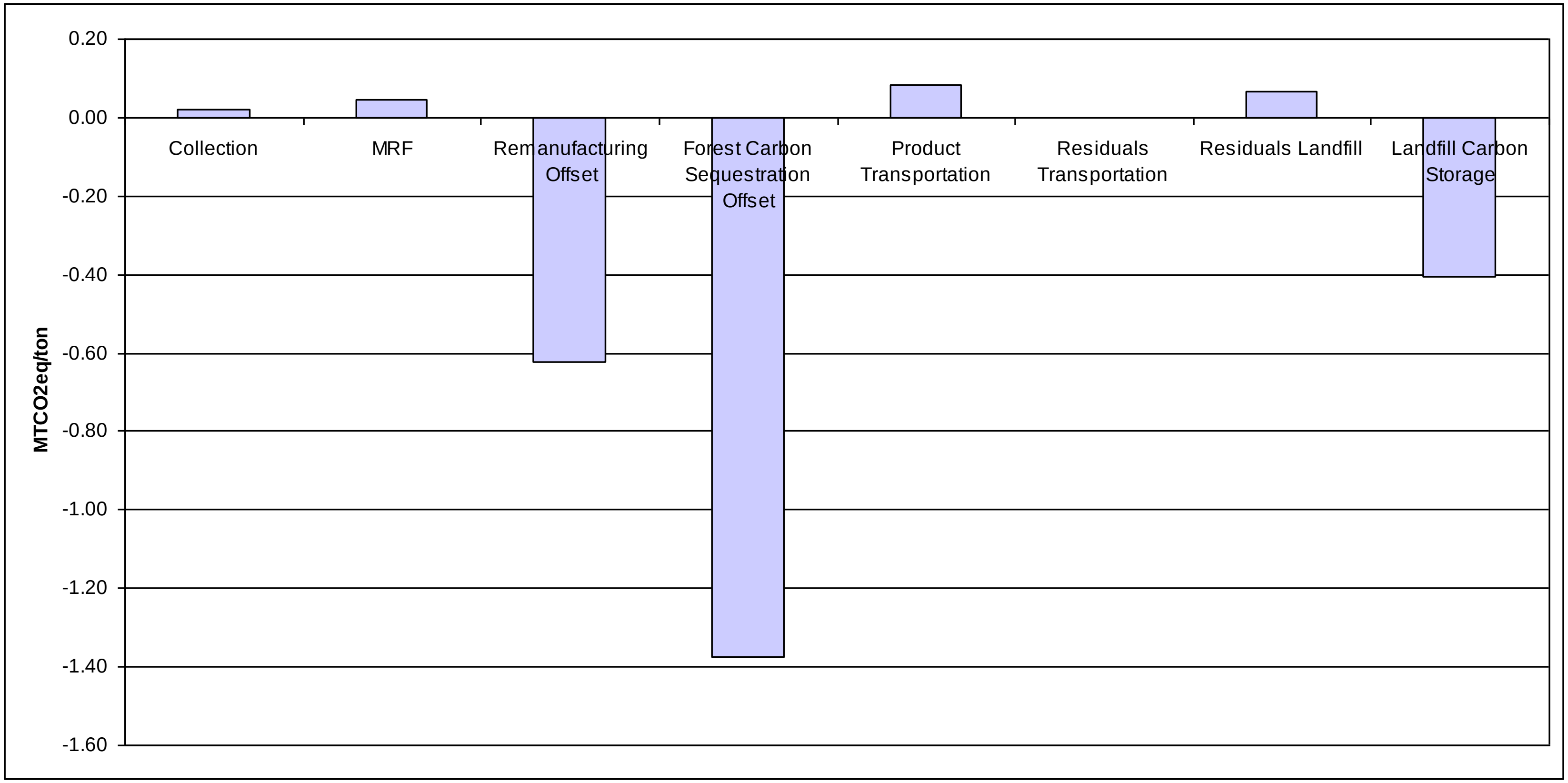

Figure 3-3. Components of the Net GHG Emission Factor for Newsprint Multi-MRF Recycling

Breakdown of GHG Emission Factor for Newsprint Recycling

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Example of the GHG emissions and energy consumption factors developed for newsprint.

Figure 3-3 illustrates a significant component for newsprint recycling is the associated forest carbon sequestration offset, which was obtained from the U.S. EPA 2006 update of *Greenhouse Gas Sources and Sinks for Municipal Solid Waste Management*. After the forest carbon sequestration factor, the other top three factors include remanufacturing offsets and landfill carbon storage associated with the disposal of newsprint residuals from the MRF.

Scenario Results

Net Energy – Landfill Baseline

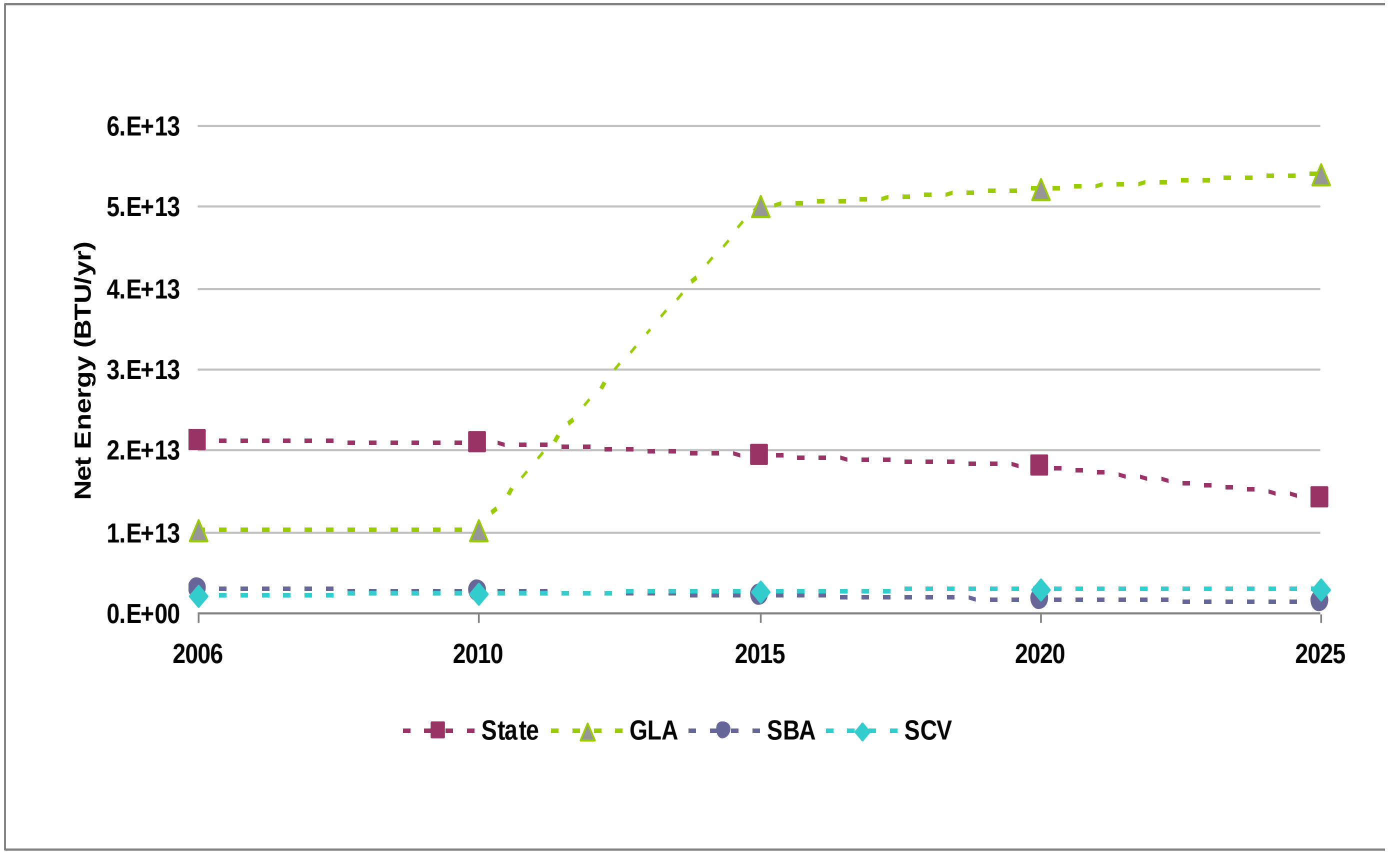

Figure 5.2. Net Energy Consumption for the Baseline Landfill Scenario.

Net Energy – Landfill Baseline

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Figure 5.2. Baseline Landfill Scenario Energy Consumption Results

Figure 5.2 shows the net energy consumption results associated with the baseline landfill scenario. The results include energy consumed in the collection, transport, and disposal of waste less any energy produced from the collection and utilization of landfill gas for producing electrical energy and/or LNG and less energy savings from beneficial offsets via materials recycling and compost application. The sharp increase in the GLA region reflects the increase in energy consumption to transport waste to the Mesquite Landfill in 2015. In other regions and the State, there is a slight decrease in energy consumption during the study periods due to expected increase in landfill gas to energy projects.

Net Carbon Emissions – Landfill Baseline

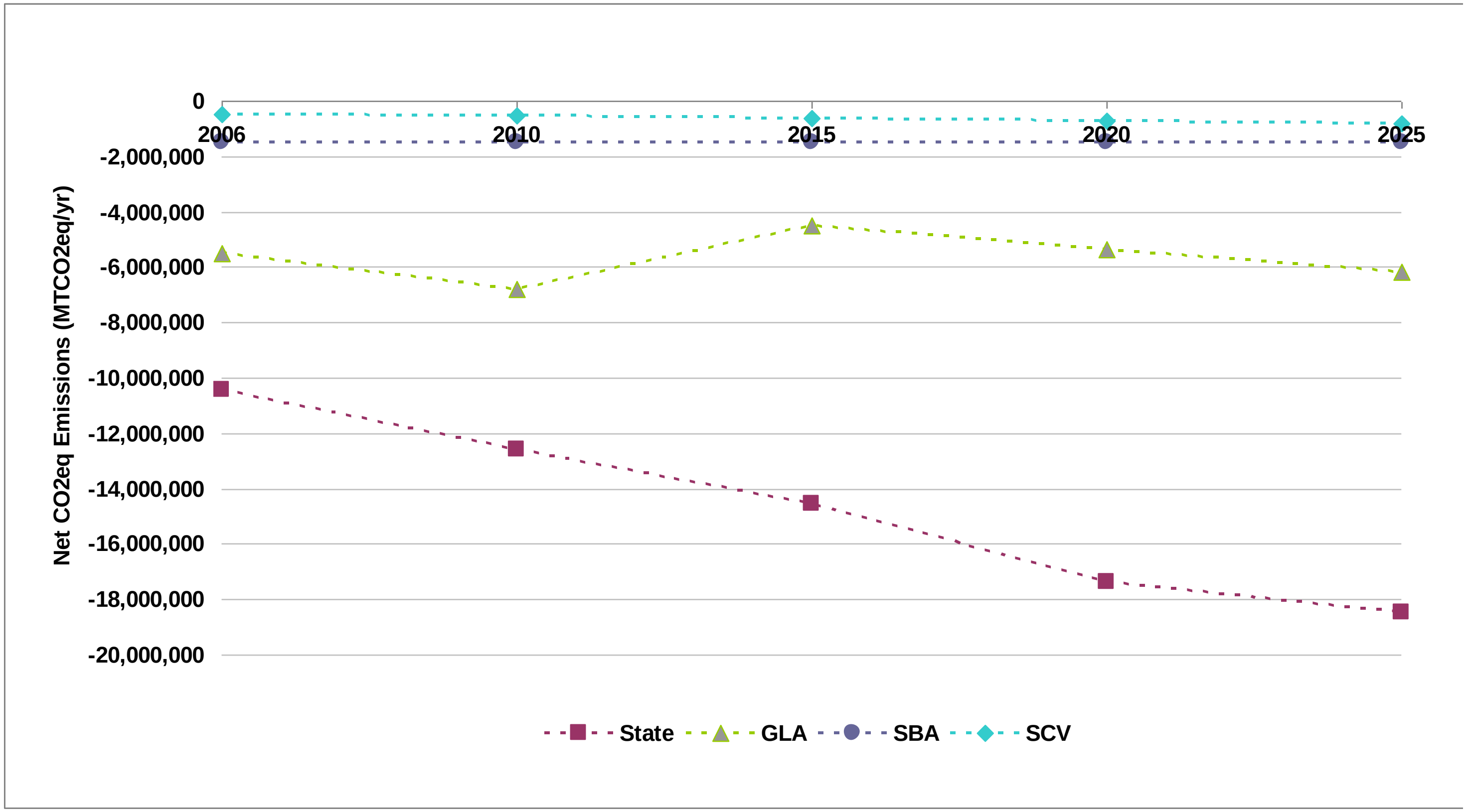

Figure 5.3. Net GHG Emissions for Baseline Landfill Scenario.

Net Carbon Emissions – Landfill Baseline

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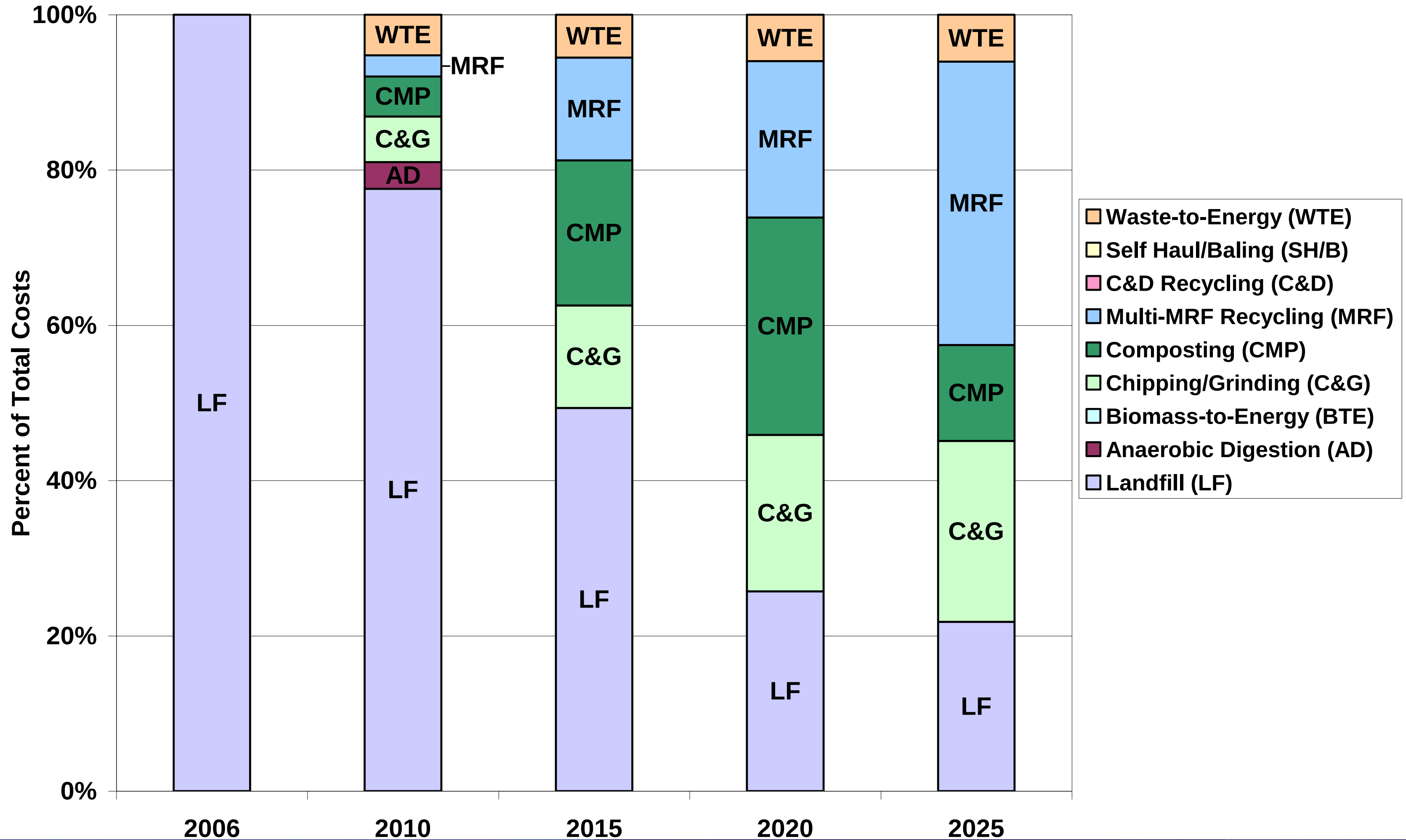
Figure 5.3 Baseline Landfill Scenario GHG Emission Results

GHG emission results for the baseline scenario, as illustrated in **Figure 5.3**, include GHG emissions associated with the collection, transport, and disposal of waste less any offsets of GHG emissions associated with energy produced from the collection and utilization of landfill gas for producing electrical energy and/or LNG. In addition, any biogenic carbon that does not decompose in the landfill is credited as long-term storage. The baseline landfill scenarios for the SBA and SCV regions exhibit a slight net GHG emissions savings or avoidance. This means that more GHG emissions are saved or avoided than GHG emissions produced via the management of waste. The GLA region and the State have more pronounced GHG emissions offsets due primarily to the absolute tonnage of waste managed by each.

Min Cost – State Mass Flow



Min Cost – State Mass Flow

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Waste Tonnage to Different Waste Management Processes, Minimum Cost Scenario, State

The sum of all the costs of processing materials under each minimum cost alternative resulted in the minimum cost alternative scenario for a given year. This figure summarizes the tonnage flow to different waste management alternatives based on the minimum cost objective and waste diversion targets.

Net Energy – Min Cost Scenario

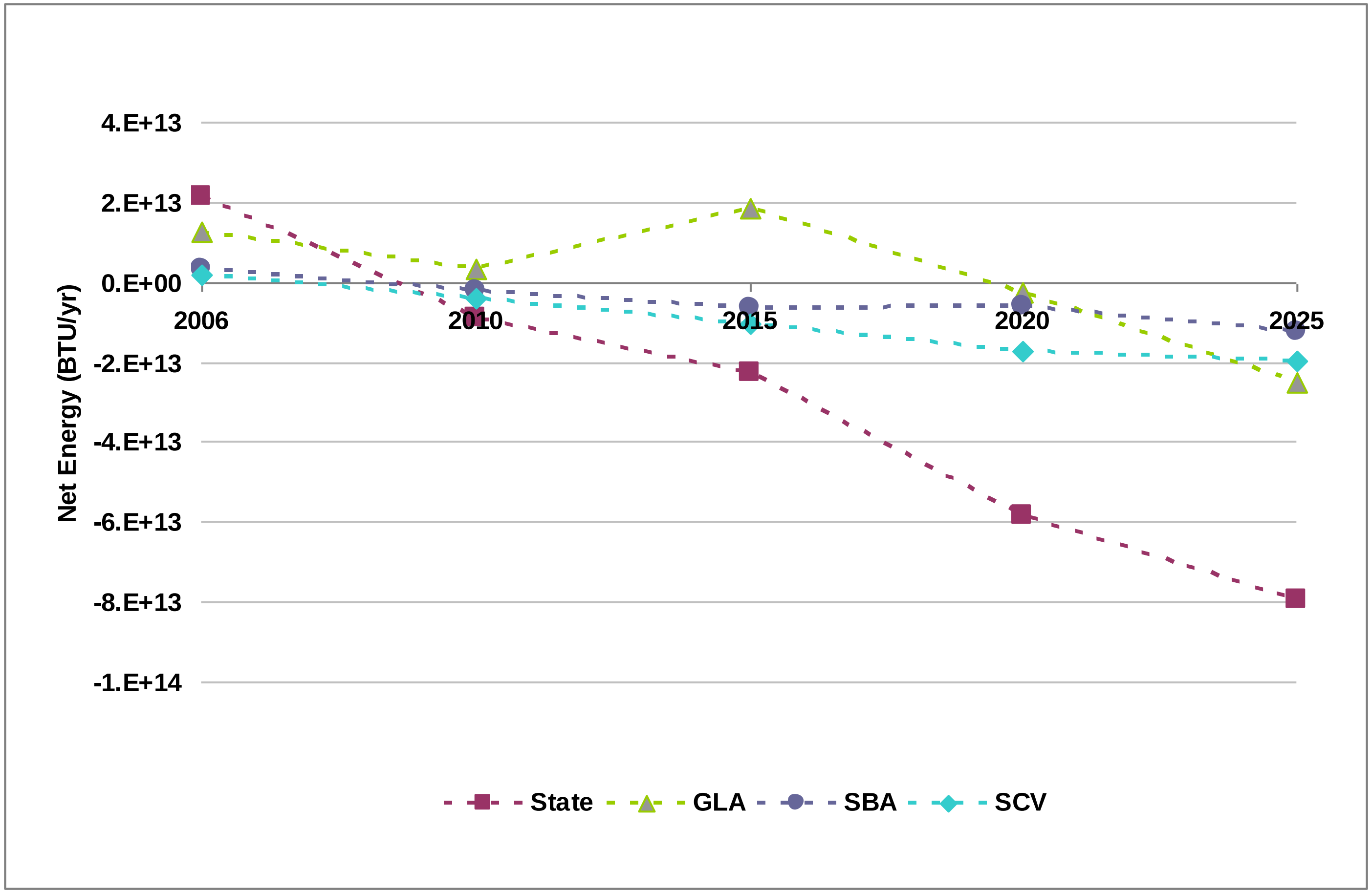

Figure 5.10. Net Energy Consumption for Minimum Cost Scenario.

Net Energy – Min Cost Scenario

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Figure 5-10. Net Energy Consumption for Minimum Cost Scenario

Figure 5-10 provides a summary illustration for the minimum cost scenario energy results. Detailed results for net energy are included in Attachment RTI3. The results shown represent the net difference between the baseline scenario and the minimum cost scenario results. The results also represent net values and include all energy consumed from the collection to final disposition of the materials. Any energy produced by waste management processes (e.g., AD, BTE, landfill gas-to-energy, WTE) is netted out the results, which leads to the net energy savings values. The results show that by managing waste according to the minimum cost scenario, net energy savings can be achieved by the study regions and more significant energy savings can be achieved at the State level.

In year 2015 to 2025, there is a significant increase in materials recycling (versus composting and chipping and grinding in the years 2006 to 2015) to meet diversion targets. Since recycling in general exhibits significantly larger energy savings than composting and chipping and grinding, a pronounced increase in the rate of energy savings is seen in the later study period years (i.e., 2015 to 2025). Also, as seen in the baseline scenario, the GLA region exhibits a sharp rise in energy consumption in 2015 corresponding with the closing of the Puente Hills landfill and the need for long-haul transport of waste to the Mesquite landfill.

Net Carbon Emissions – Min Cost Scenario

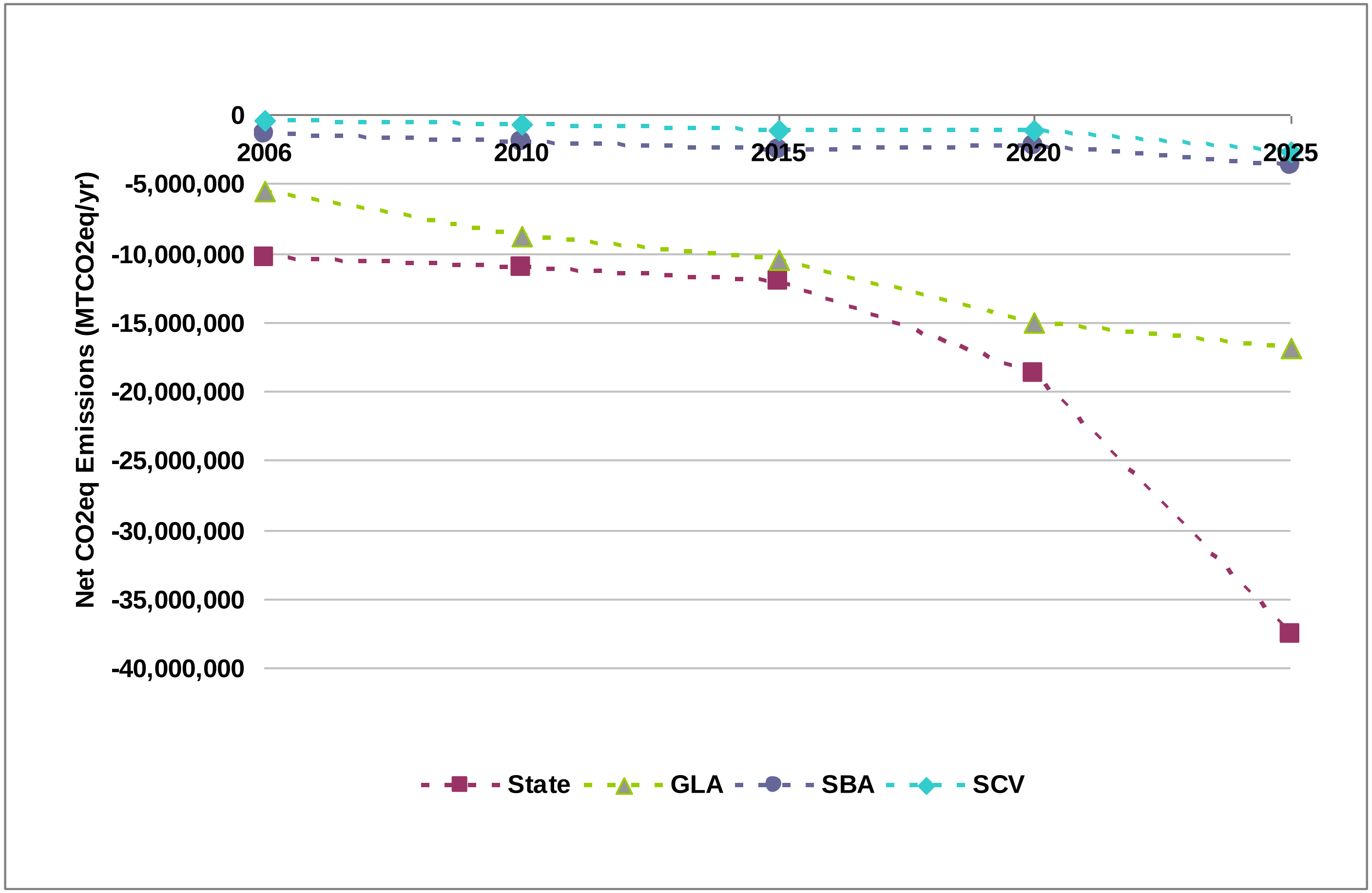

Figure 5.11. Net GHG Emissions for Minimum Cost Scenario.

Net Carbon Emissions – Min Cost Scenario

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Figure 5-11. Net GHG Emissions for Minimum Cost Scenario

Figure 5.11 provides a summary illustration for the minimum cost scenario GHG emission results. Detailed results for net GHG emissions are included in Attachment RTI3. The results shown represent the net difference between the baseline scenario and the minimum cost scenario results. The results also represent net values and include all GHG emissions from the collection to final disposition of the materials. Any GHG emission offsets by virtue of energy and/or materials by waste management processes are netted out the results, as well as carbon storage and sequestration, which leads to the net GHG emission savings values as shown in Figure 5.11. The results show that by managing waste according to the minimum cost scenario, net GHG emission savings or avoidance can be achieved by the study regions. More significant GHG emission savings can be achieved in the GLA region and at the State level due to the larger tonnages of waste managed as compared to the SBA and SCV regions.

Similar to the energy results, in year 2015 to 2025 there is a more pronounced increase GHG emission savings due to the increase in materials recycling (versus composting and chipping and grinding in the years 2006 to 2015) to meet diversion targets. Unlike the energy results, however, the GLA region does not exhibit a sharp rise in GHG emissions in 2015 corresponding with the closing of the Puente Hills landfill and the need for long-haul transport of waste to the Mesquite landfill. The reason for this is that on a GHG emission basis, transportation is less significant in the context of the overall waste management system as compared to other GHG sources and sinks (e.g., landfill gas emissions, energy and material recycling offsets).

Min GHG – State Mass Flow

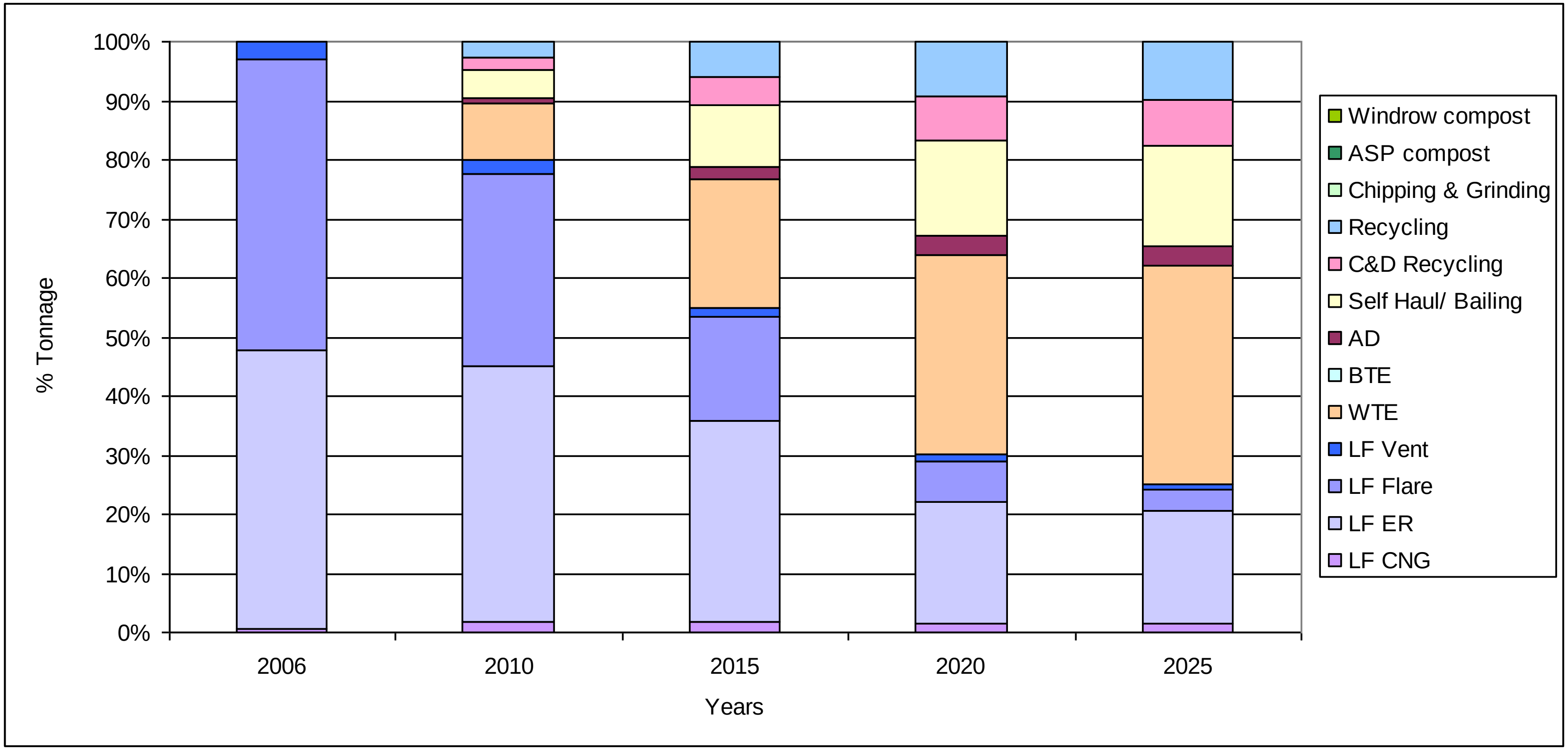

Figure 5.15. Waste Tonnage to Different Waste Management Processes, Minimum GHG Emissions Scenario, State.

Min GHG – State Mass Flow

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Figure 5.15. Waste Tonnage to Different Waste Management Processes, Minimum GHG Emissions Scenario, State

The mass flows shown in Figure 5.15 illustrates the waste flow to different alternatives that meet the minimum GHG emissions scenario objective. The State tonnage details are provided in Table 5.19 and all tonnage details are provided in Attachment RWB-3. In general, the alternatives resulting in minimum GHG emissions include materials and energy recovery processes.

In regions where WTE is currently available, the trend appears to be utilizing WTE and materials recycling to achieve the minimum GHG objective. In regions where WTE is not currently available, recycling with AD and BTE is the primary alternative for meeting the minimum GHG emissions objective. In later years when WTE becomes possible to implement, the minimum GHG emissions strategy is generally one that includes WTE and recycling. Also note that in all regions, moving from 2006 to 2025, landfill gas venting and flaring are almost completed phased out in favor of landfill gas-to-energy alternatives.

Net Energy – Min GHG Scenario

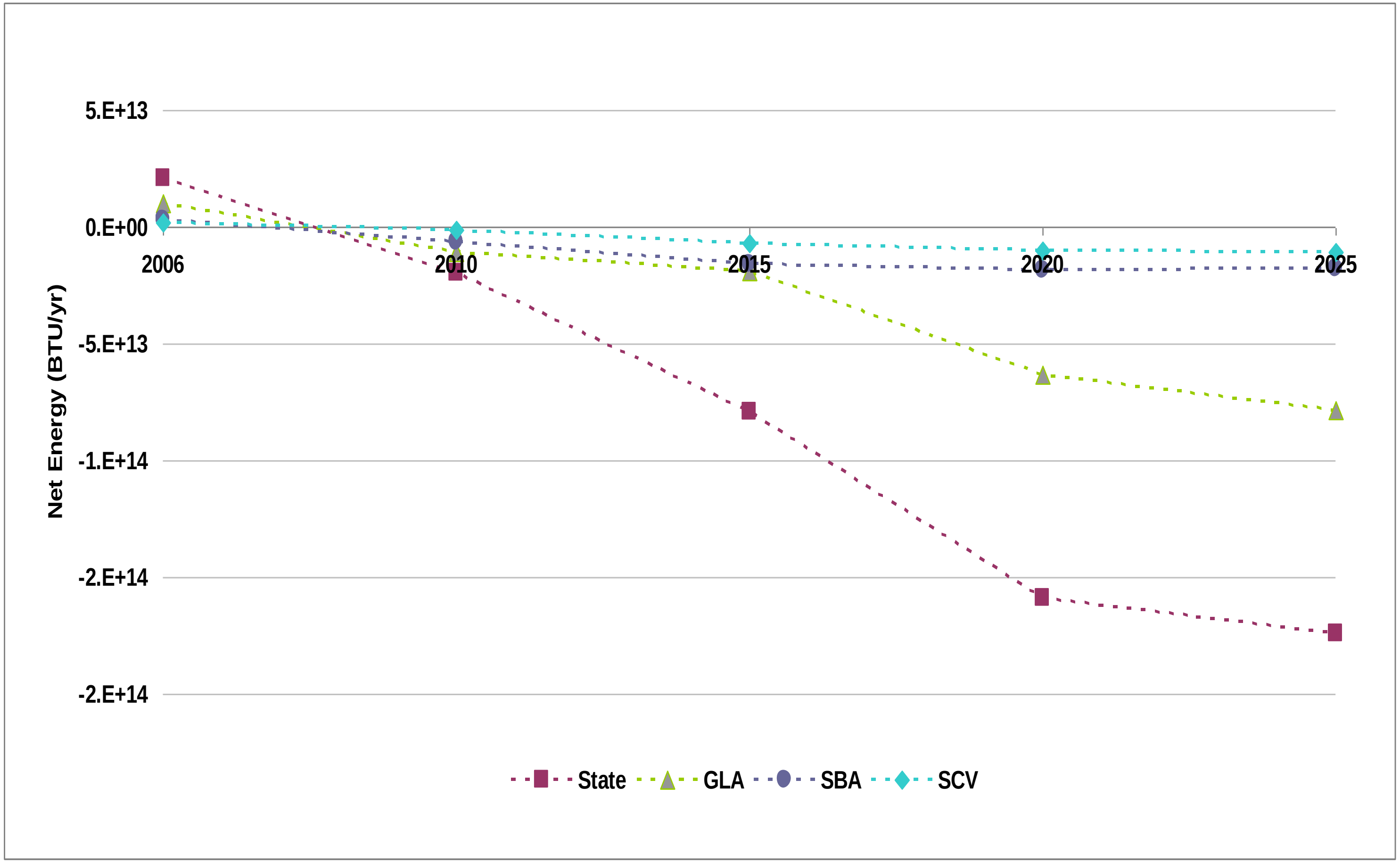

Figure 5.18. Net Energy for Minimum GHG Emissions Scenario.

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Net Energy – Min GHG Scenario

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Figure 5.18. Net Energy for Minimum GHG Emissions Scenario

Figure 5.18 provides a summary illustration for the minimum GHG emissions scenario energy results. Detailed energy results for this scenario are included in Attachment RTI4. The results shown represent the net difference between the baseline (landfill status quo) and the minimum GHG emission scenario results. The results also represent net values and include all energy consumed from the collection to final disposition of the materials. Any energy produced (e.g., AD, BTE, landfill gas-to-energy, WTE) or avoided (e.g., compost and recycling related beneficial offsets) by waste management processes is netted out the results, which leads to the net energy savings values. The results show that by managing waste according to the minimum GHG emission scenario, net energy savings can be achieved by the study regions and more significant energy savings can be achieved at the State level.

In year 2015 to 2025, there is a significant increase in materials and energy recovery (via WTE) to meet diversion targets and minimum GHG emission objectives. Since materials recycling and WTE in general exhibit significantly larger energy savings than composting and chipping and grinding, a pronounced increase in the rate of energy savings is seen in the later study period years (i.e., 2015 to 2025). Also, as seen in the baseline scenario, the GLA region exhibits a flatness in energy consumption in 2015 corresponding with the closing of the Puente Hills landfill and the need for long-haul transport of waste to the Mesquite landfill. As materials recycling and WTE increase in the GLA region in 2020 and 2025, net energy savings increase sharply.

Net Carbon Emissions – Min GHG Scenario

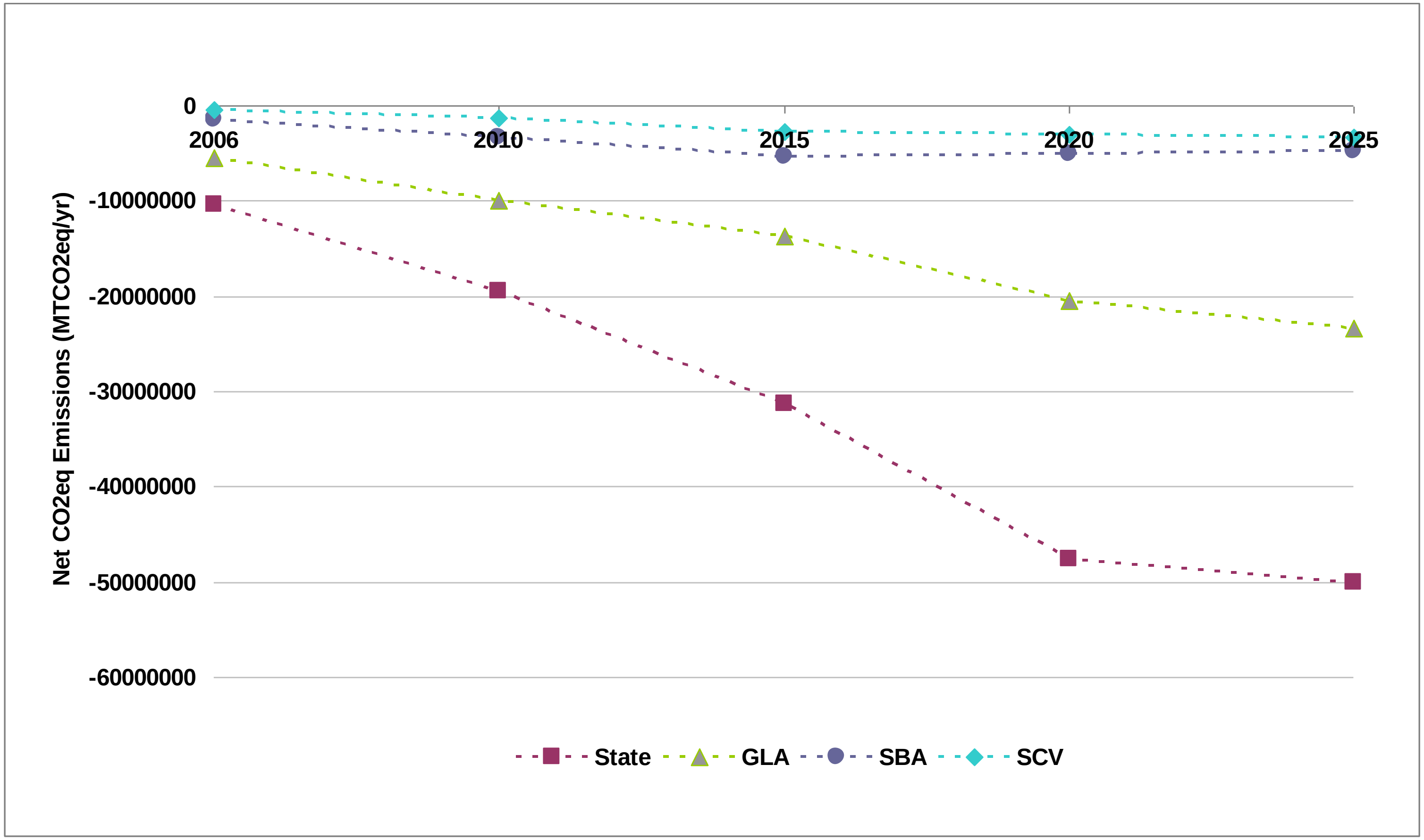

Figure 5.19. Net GHG Emissions for Minimum GHG Emission Scenario.

Net Carbon Emissions – Min GHG Scenario

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Figure 5.18. Net GHG Emissions for Minimum GHG Emissions Scenario

Figure 5-19 provides a summary illustration for the minimum GHG emissions scenario net GHG emission results. Detailed GHG emission results are included in Attachment RTI4. The results shown represent the net difference between the baseline scenario and the minimum GHG emission scenario results. The results also represent net values and include all GHG emissions from the collection to final disposition of the materials. Any GHG emission offsets by virtue of energy and/or materials by waste management processes are netted out the results, as well as carbon storage and sequestration, which leads to the net GHG emission savings values. The results show that by managing waste according to the minimum cost scenario, net GHG emission savings or avoidance can be achieved by the study regions. More significant GHG emission savings can be achieved in the GLA region and at the State level due to the larger tonnages of waste managed as compared to the SBA and SCV regions.

Similar to the energy results, in year 2015 to 2025 there is a more pronounced increase GHG emission savings due to the increase in materials recycling and WTE to meet diversion targets. Unlike the energy results, however, the GLA region does not exhibit a sharp drop in GHG emissions in 2015 corresponding with the closing of the Puente Hills landfill and the need for long-haul transport of waste to the Mesquite landfill. The reason for this is that on a GHG emission basis, transportation is less significant in the context of the overall waste management system as compared to other GHG sources and sinks.

Min Cost While Meeting GHG Reduction Targets – State Mass Flow

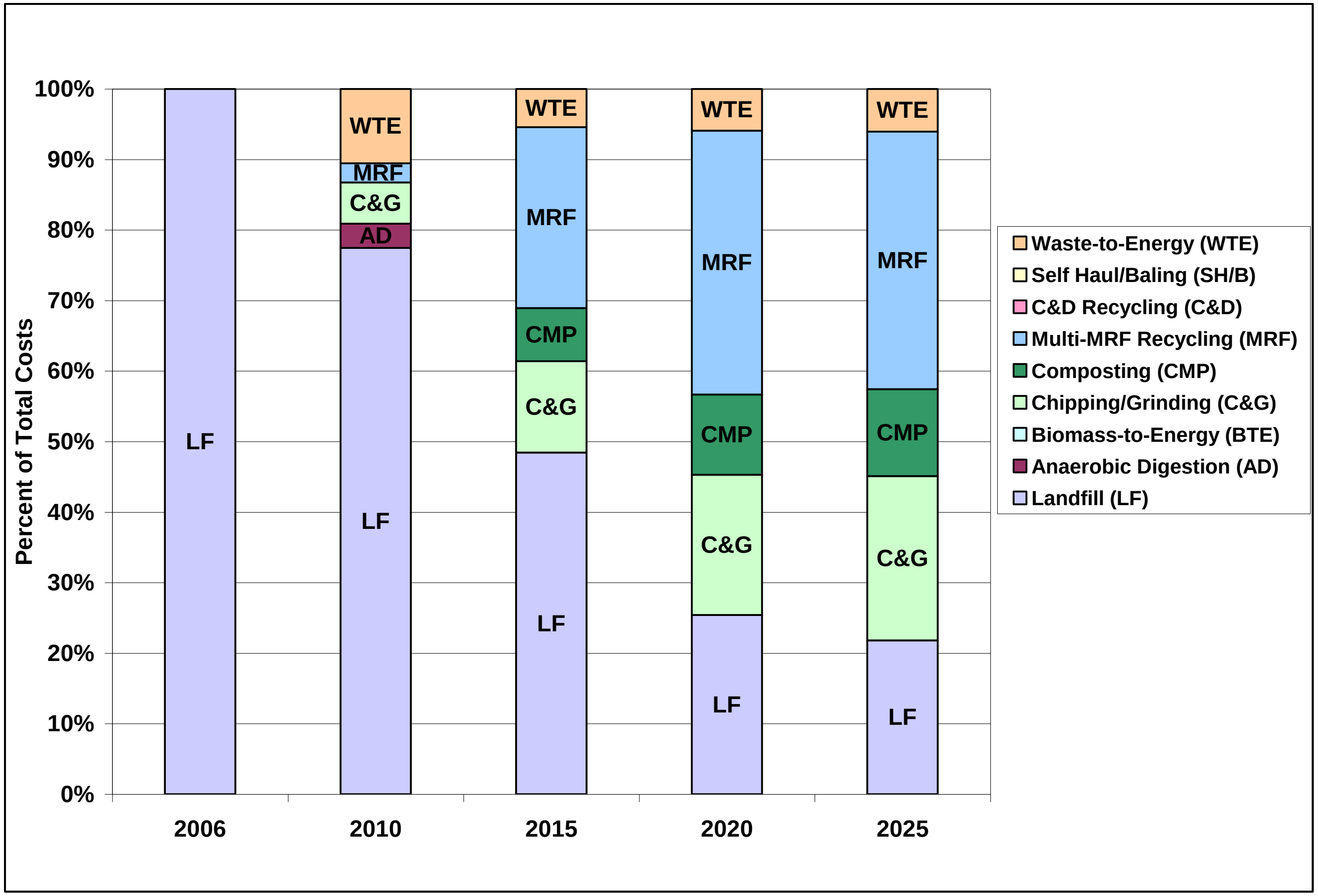

Figure 5.21 Minimum Cost While Achieving State GHG Emission Reduction Targets by Alternative - State

Min Cost While Meeting GHG Reduction Targets – State Mass Flow

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Figure 5.21. Minimum Cost While Achieving State GHG Emission Reduction Targets by Alternative, State

Figure 5.21 graphically depicts the alternatives on an annual basis for the statewide minimum costs while achieving state GHG emission reductions target analysis results. In 2006 all material is going to the landfill but this amount gradually decreases to 25% over time as waste is diverted to other alternatives. The stacking order of the alternatives shown in the figure is not significant since not all waste can go to one alternative, except for WTE.

Net Energy – Min Cost Meeting GHG Reduction Targets Scenario

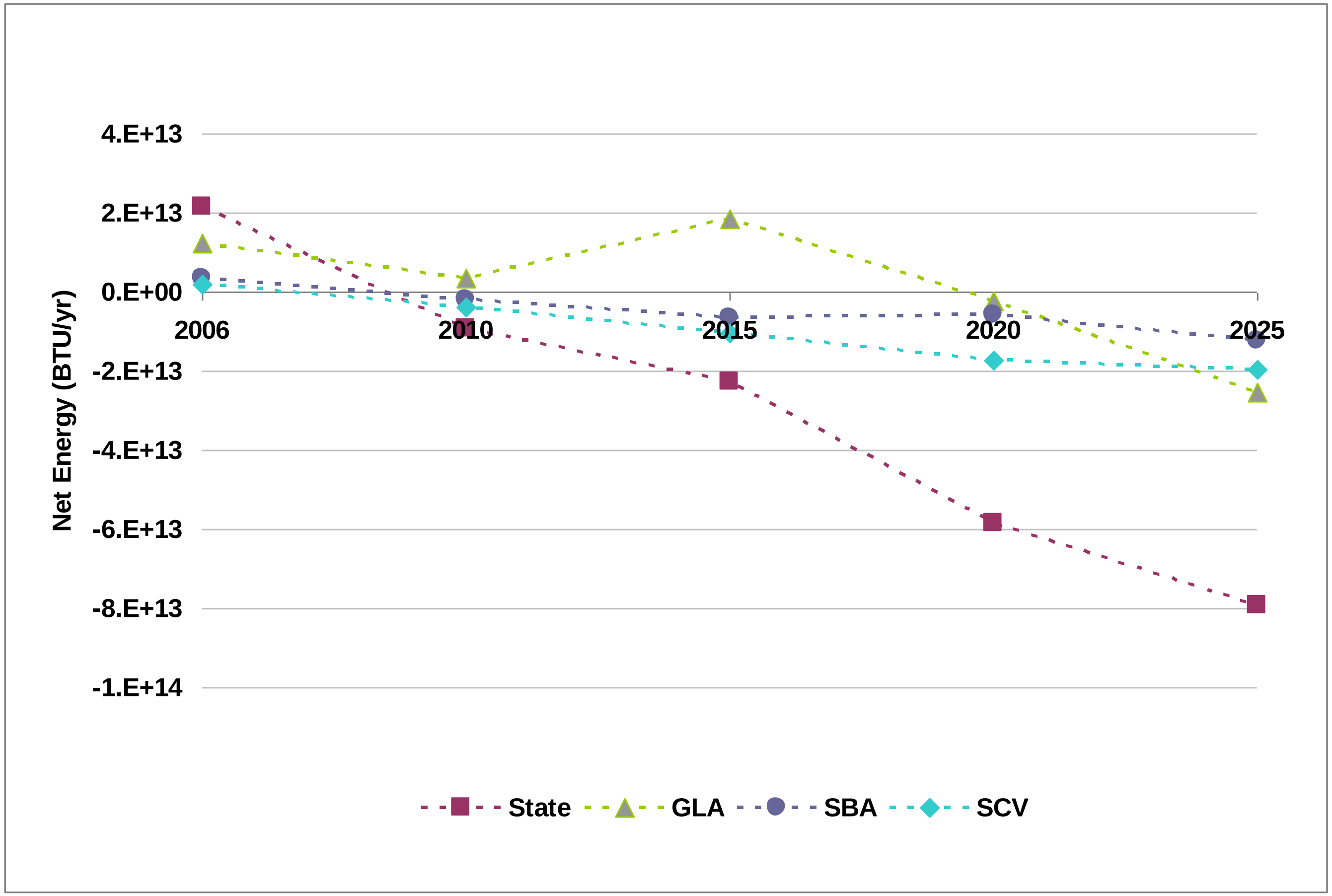

Figure 5.23. Net Energy for Minimum Cost while Achieving GHG Emission Reduction Targets Scenario.

Net Energy – Min Cost Meeting GHG Reduction Targets Scenario

To comply with accessibility requirements, this slide has been added to the original presentation to describe the graphic on the previous slide.

Figure 5.23. Net Energy for Minimum Cost While Achieving GHG Emission Reduction Targets Scenario

- Figure 5-23 provides a summary of the net energy consumption results corresponding to this scenario. The results also represent net values and include all energy consumed from the collection to final disposition of the materials. Any energy produced (e.g., AD, BTE, landfill gas-to-energy, WTE) or avoided (e.g., compost and recycling related beneficial offsets) by waste management processes is netted out the results, which leads to the net energy savings values.
- The results show a similar pattern to those in the minimum cost scenario which is expected. Similar to the minimum cost scenario results in year 2015 to 2025, there is a significant increase in materials recycling (versus composting and chipping and grinding in the years 2006 to 2015) to meet GHG emissions targets. Since recycling in general exhibits significantly larger energy savings than composting and chipping and grinding, a pronounced increase in the rate of energy savings is seen in the later study period years (i.e., 2015 to 2025). Also, as seen in the other scenarios, the GLA region exhibits a sharp rise in energy consumption in 2015 corresponding with the closing of the Puente Hills landfill and the need for long-haul transport of waste to the Mesquite landfill.

Net Carbon Emissions – Min Cost Meeting GHG Reduction Targets Scenario

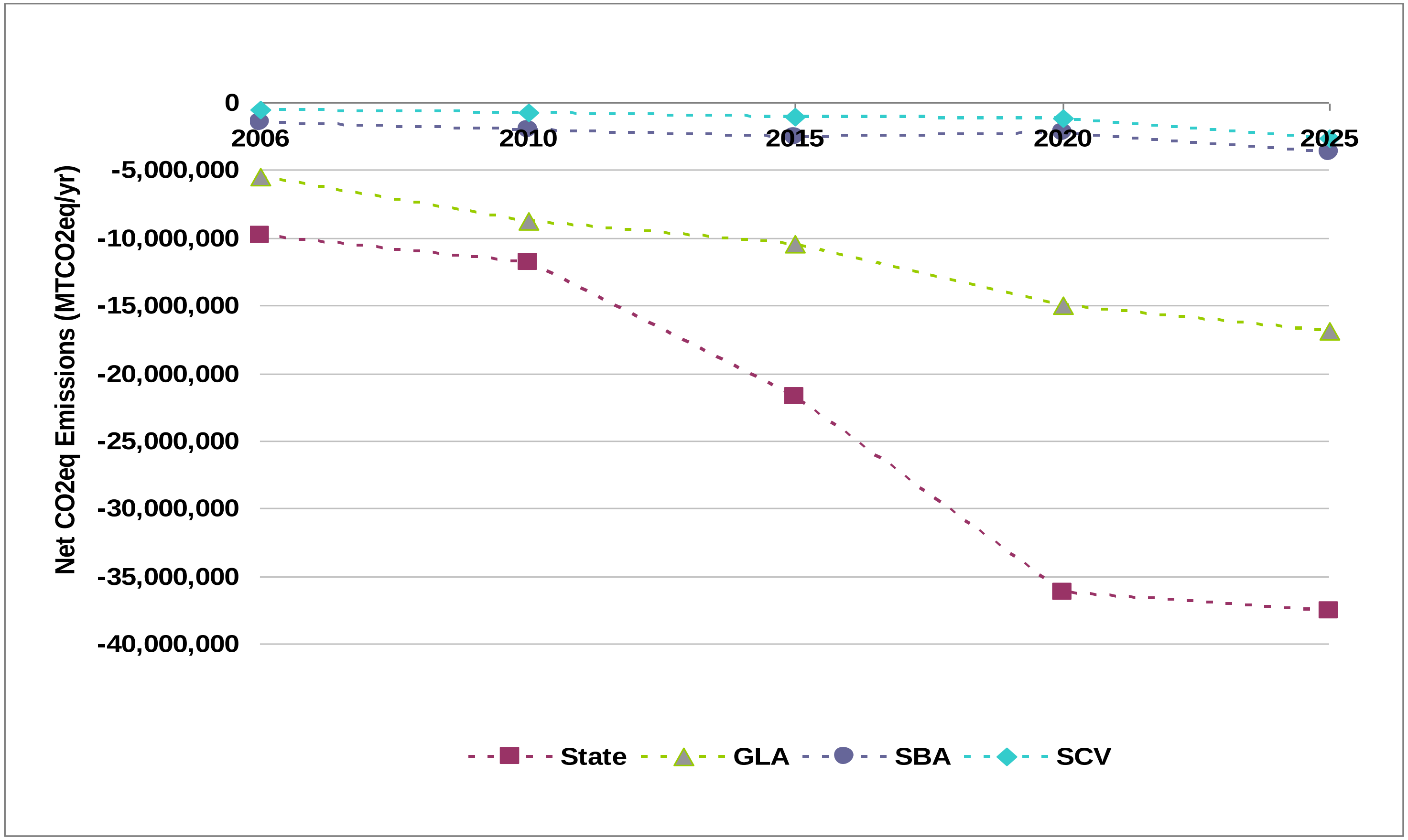

Figure 5.24. Net GHG Emissions for Minimum Cost while Achieving CO2-eq Targets Scenario.

Net Carbon Emissions – Min Cost Meeting GHG Reduction Targets Scenario

To comply with accessibility requirements, this slide has been added to the original presentation to describe the graphic on the previous slide.

Figure 5.24. Net GHG Emissions for Minimum Cost while Achieving CO2-eq Targets Scenario

Figure 5.24 provides a summary illustration for the net GHG emissions results corresponding to this scenario. The results shown represent the net difference between the baseline scenario and the minimum GHG emission scenario results. The results also represent net values and include all GHG emissions from the collection to final disposition of the materials. Any GHG emission offsets by virtue of energy and/or materials by waste management processes are netted out the results, as well as carbon storage and sequestration, which leads to the net GHG emission savings values as shown in Figure 5.24. In general, the results show a similar pattern to the minimum cost scenario he results where more significant GHG emission savings are achieved in the GLA region and at the State level due to the larger tonnages of waste managed as compared to the SBA and SCV regions.

Similar to the energy results, in year 2015 to 2025 there is a more pronounced increase GHG emission savings due to the increase in materials recycling and WTE (versus composting and chipping and grinding in the years 2006 to 2015) to meet GHG emissions targets. Unlike the energy results, however, the GLA region does not exhibit a sharp drop in GHG emissions in 2015 corresponding with the closing of the Puente Hills landfill and the need for long-haul transport of waste to the Mesquite landfill. The reason for this is that on a GHG emission basis, transportation is less significant in the context of the overall waste management system as compared to other GHG sources and sinks (e.g., landfill gas emissions, energy and material recycling offsets).

Min Energy – State Mass Flow

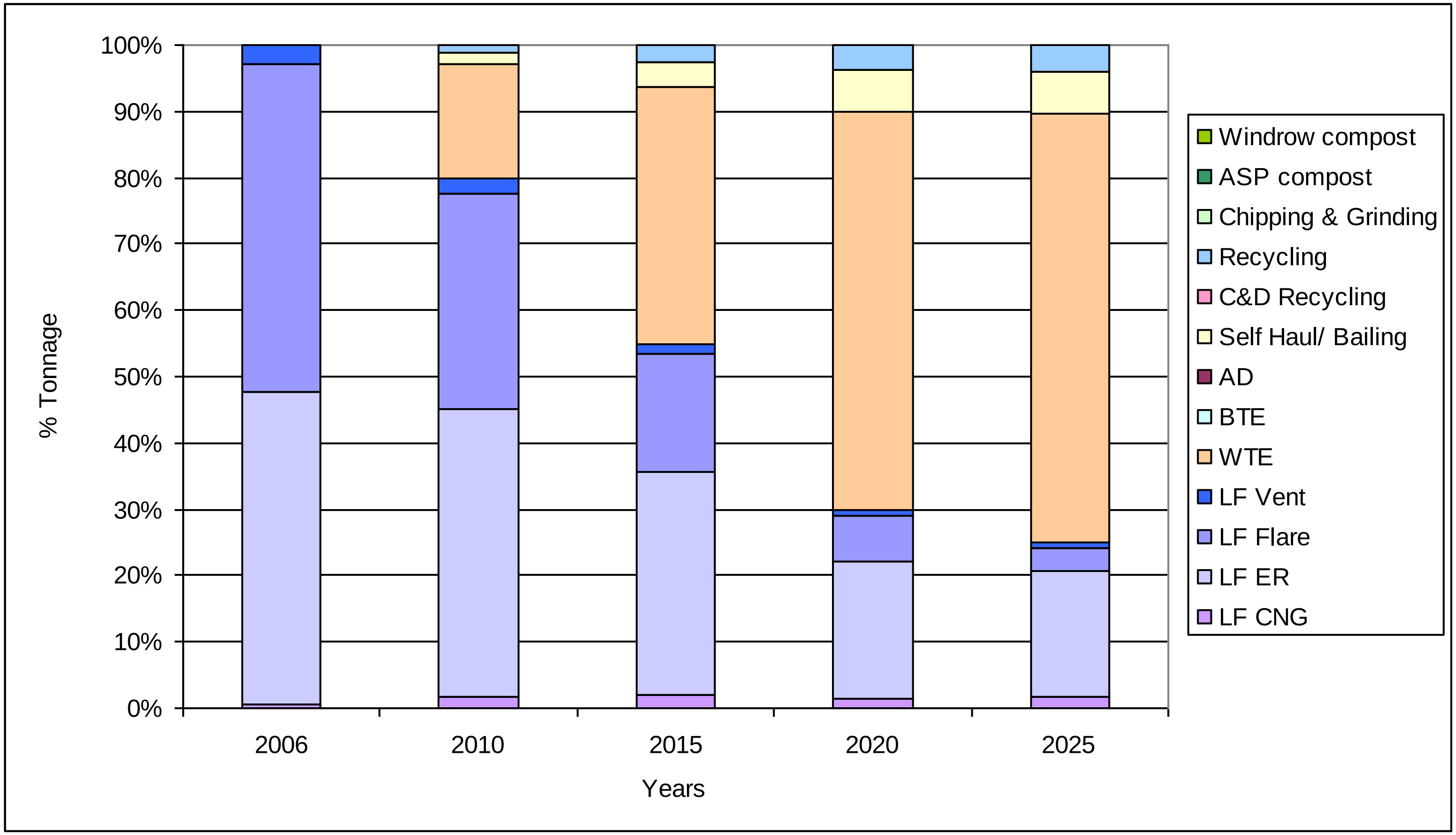

Figure 5.28. Waste Tonnage to Different Waste Management Processes, Minimum Energy Consumption Scenario, State.

Min Energy – State Mass Flow

To comply with accessibility requirements, this slide has been added to the original presentation to describe the graphic on the previous slide.

Figure 5.28. Waste Tonnage to Different Waste Management Processes, Minimum Energy Consumption Scenario, State

The mass flows shown in Figure 5.28 illustrates the waste flow to different alternatives that meet the minimum energy consumption scenario objective. In general, the alternatives resulting in minimum energy consumption generally in energy recovery processes and to a lesser extent, materials recycling. In regions where WTE is current available, the trend appears to be utilizing WTE and some materials recycling to achieve the minimum energy consumption objective. In regions where WTE is not currently available, recycling with AD and BTE is the primary alternative for meeting the minimum energy consumption objective. In later years when WTE becomes possible to implement, the minimum energy strategy is generally one that includes WTE and recycling. Also note that in all regions, moving from 2006 to 2025, landfill gas venting and flaring are almost completed phased out in favor of landfill gas-to-energy alternatives.

Net Energy – Min Energy Scenario

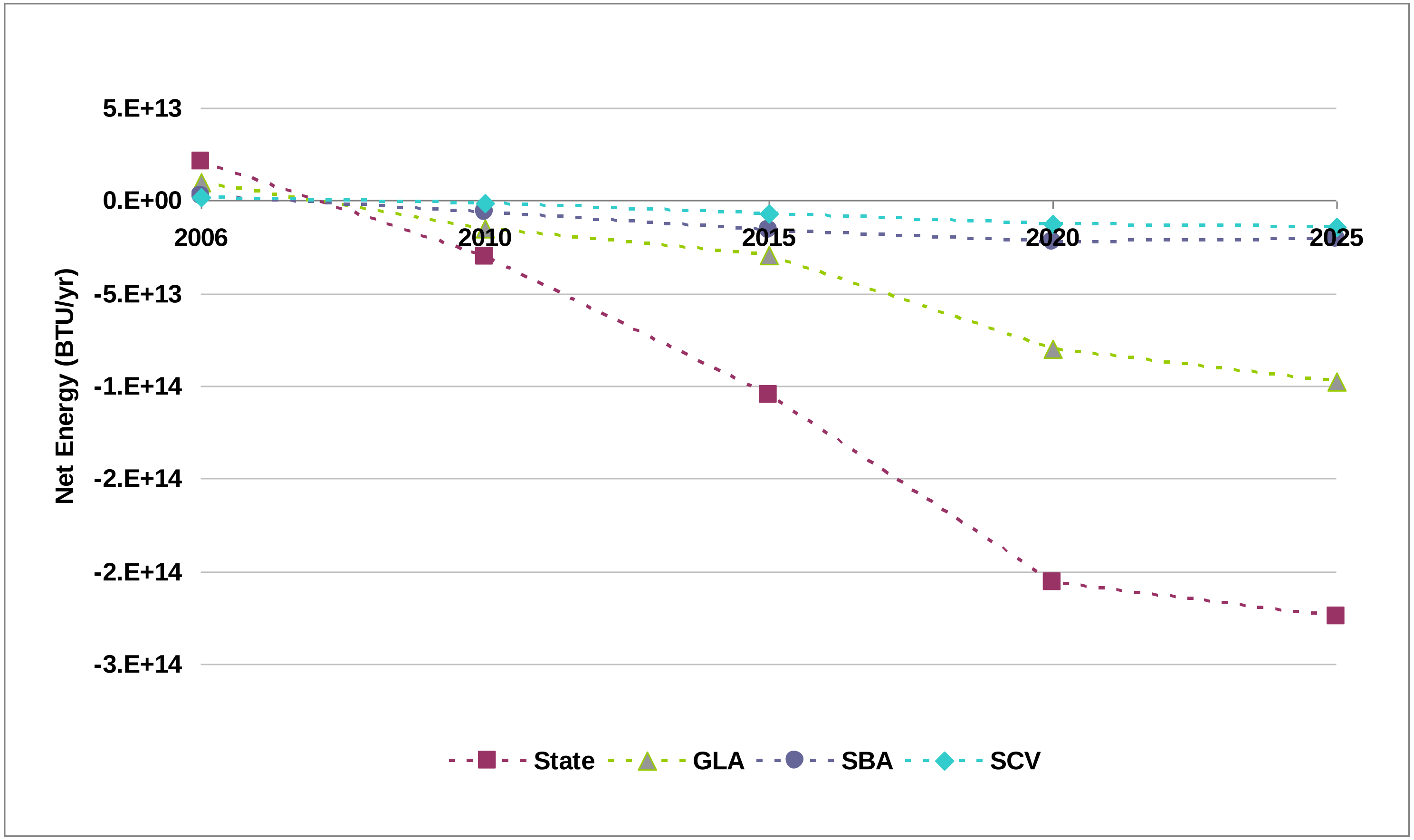

Figure 5.31. Net Energy for Minimum Energy Consumption Scenario.

Net Energy – Min Energy Scenario

To comply with accessibility requirements, this slide has been added to the original presentation to describe the graphic on the previous slide.

Figure 5.31. Net Energy for Minimum Energy Consumption Scenario

Figure 5.31 provides a summary illustration of the net energy consumption results. Detailed energy results for this scenario are included in Attachment RTI6. The results shown represent the net difference between the baseline and the minimum energy consumption scenario results. The results also represent net values and include all energy consumed from the collection to final disposition of the materials. Any energy produced or avoided by waste management processes is netted out the results, which leads to the net energy savings values. The results show that net energy savings can be achieved in the SBA and SCV study regions and more significant energy savings can be achieved in the GLA region and at the State level, due primarily to the significantly greater tonnages of waste managed in the GLA region and State.

In year 2015 to 2025, there is a significant increase in materials and energy recovery (via WTE) to meet diversion targets and minimum energy consumption objectives. Since materials recycling and WTE in general exhibit significantly larger energy savings than composting and chipping and grinding, a pronounced increase in the rate of energy savings is seen in the later study period years (i.e., 2015 to 2025). Also, as seen in the baseline scenario, the GLA region exhibits a flatness in energy consumption in 2015 corresponding with the closing of the Puente Hills landfill and the need for long-haul transport of waste to the Mesquite landfill. As materials recycling and WTE increase in the GLA region in 2020 and 2025, net energy savings increase sharply.

Net Carbon Emissions – Min Energy Scenario

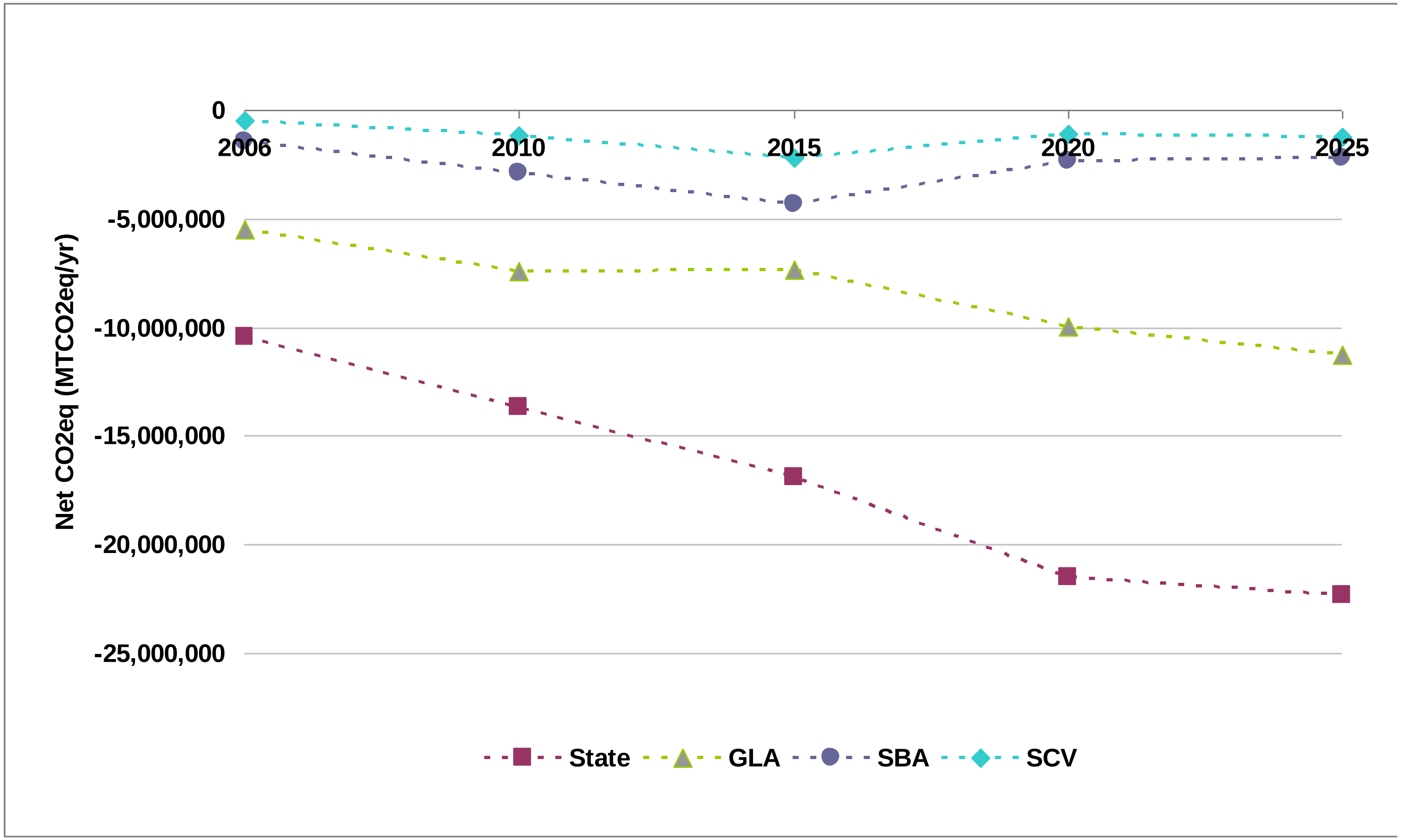

Figure 5.32. Net GHG Emissions for Minimum Energy Consumption Scenario.

Net Carbon Emissions – Min Energy Scenario

To comply with accessibility requirements, this slide has been added to the original presentation to describe the graphic on the previous slide.

Figure 5.32. Net GHG Emissions for Minimum Energy Consumption Scenario

Figure 5.32 provides a summary illustration for the minimum energy consumption scenario net GHG emission results. Detailed GHG emissions results for this scenario are included in Attachment RTI6. The results shown represent the net difference between the baseline scenario and the minimum energy consumption scenario results. The results also represent net values and include all GHG emissions from the collection to final disposition of the materials. Any GHG emission offsets by virtue of energy and/or materials by waste management processes are netted out the results, as well as carbon storage and sequestration, which leads to the net GHG emission savings values. The results show that by managing waste according to the minimum energy consumption scenario, net GHG emission savings or avoidance can be achieved by the study regions. More significant GHG emission savings can be achieved in the GLA region and at the State level due to the larger tonnages of waste managed as compared to the SBA and SCV regions.

Similar to the energy results, in year 2015 to 2025 there is a more pronounced increase GHG emission savings due to the increase in materials recycling and WTE (versus composting and chipping and grinding in the years 2006 to 2015) to meet diversion targets. Unlike the energy results, however, the GLA region does not exhibit a sharp drop in GHG emissions in 2015 corresponding with the closing of the Puente Hills landfill and the need for long-haul transport of waste to the Mesquite landfill. The reason for this is that on a GHG emission basis, transportation is less significant in the context of the overall waste management system as compared to other GHG sources and sinks.

Sensitivity Analysis

Sensitivity Analysis

- Sensitivity to changes in the electricity grid mix
  - Used 25% increase in carbon-neutral fuels to match the accelerated RPS forecast from 2006 to 2025.
- Sensitivity to changes in landfill gas collection efficiency
  - Used 6% change to match difference between regional assumptions.
- Sensitivity to changes in transportation distances for the following routes
  - Collection (used 10 mile change)
  - Product transportation (used 10 mile change)
  - Residuals transportation (used 10 mile change)
- Sensitivity to changes in transportation GHG emissions as a results of low carbon fuel standards
  - Used a 10% reduction in fuel carbon intensity by 2020.

Sensitivity of Electricity Grid Mix

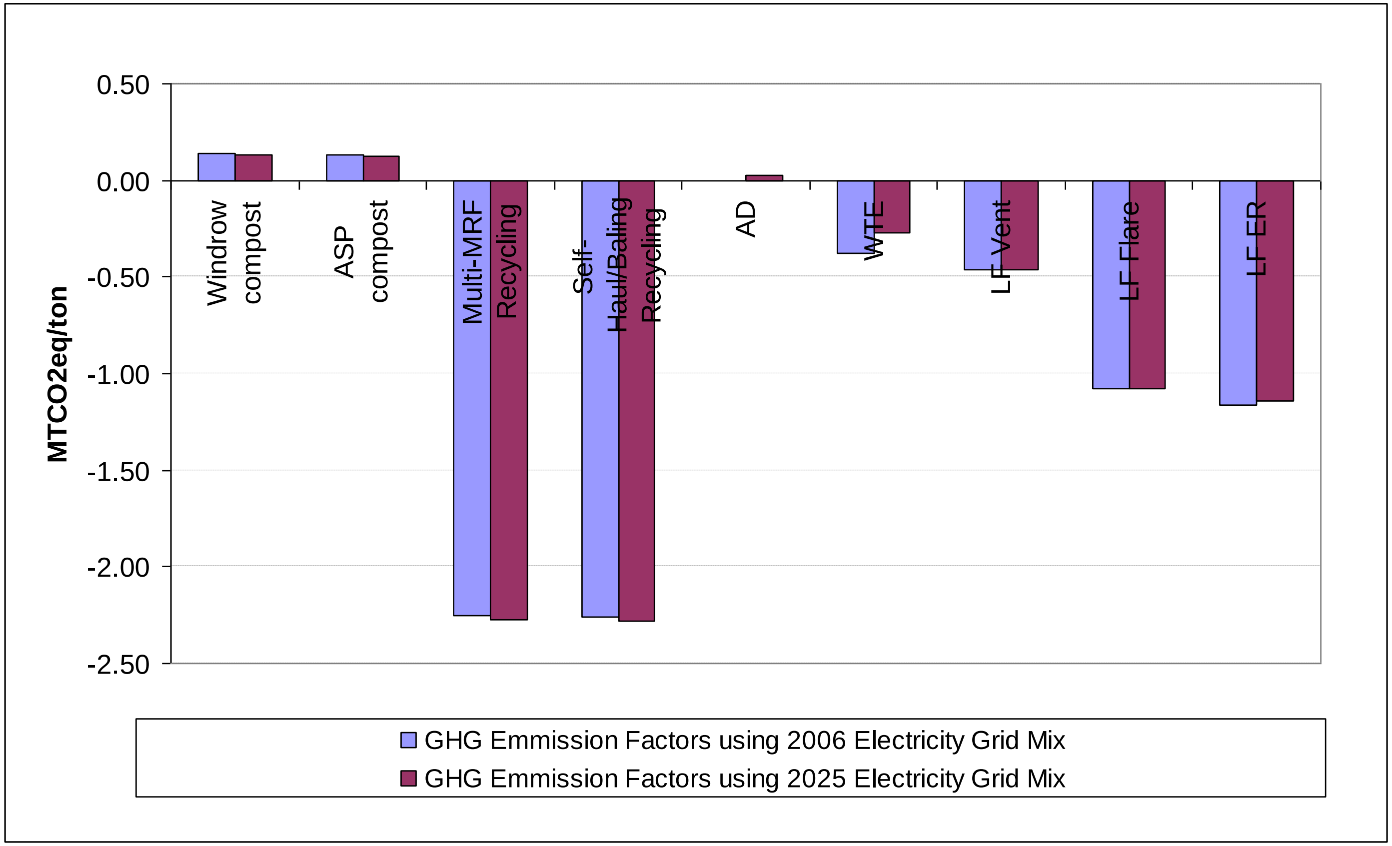

Figure 6.4. GHG Emission Factors for Newspaper Using Different Electricity Grid Mixes

Sensitivity of Electricity Grid Mix

To comply with accessibility requirements, this slide has been added to the original presentation to describe the graphic on the previous slide.

Figure 6.4. GHG Emission Factors for Newspaper Using Different Electricity Grid Mixes

Potential changes in the CA electricity grid mix were analyzed and a sensitivity analysis performed to evaluate changes in the GHG factors resulting from a reduction in the use of fossil fuels and an increase in renewable sources. Figure 6.4 presents an example of the GHG emission factors using both the 2006 and the assumed 2025 electricity grid mix and newspaper. In general, the change observed is expected to be similar (in trend) for all waste categories.

According to Figure 6.4, the ranking of the emission factors across different waste management processes is not expected to change due to the changes in the electricity grid mix assumed for year 2025.

Sensitivity of Landfill Gas Collection Efficiency

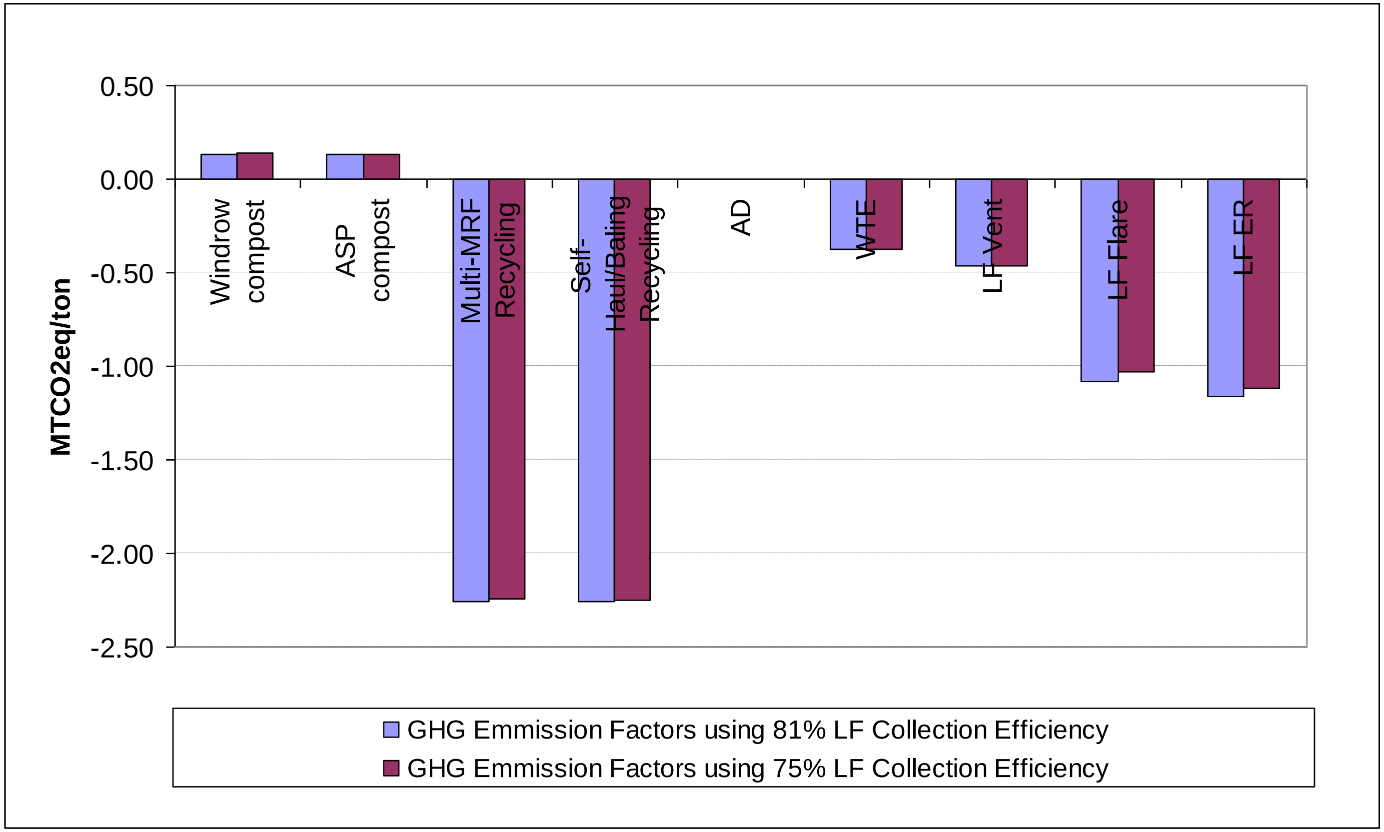

Figure 6.5. GHG Emission Factors for Newspaper Using Different Landfill Gas Collection Efficiency

Sensitivity of Landfill Gas Collection Efficiency

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Figure 6.5. GHG Emission Factors for Newspaper Using Different Landfill Gas Collection Efficiency

Sensitivity to changes in landfill gas collection efficiency were analyzed to evaluate changes in the GHG factors resulting from changes in the landfill gas collection efficiency. A 75% landfill gas collection efficiency was chosen to evaluate the changes in the emissions from the average of 81% obtained for this study. Figure 6.5 presents an example of the GHG emission factors using both 81% and 75% landfill gas collection efficiency and newspaper.

According to Figure 6.5 the ranking of the emission factors across different waste management processes is not expected to change for commonly reported landfill gas collection efficiencies ranging from 75% to 81%.

Sensitivity of Collection Distance

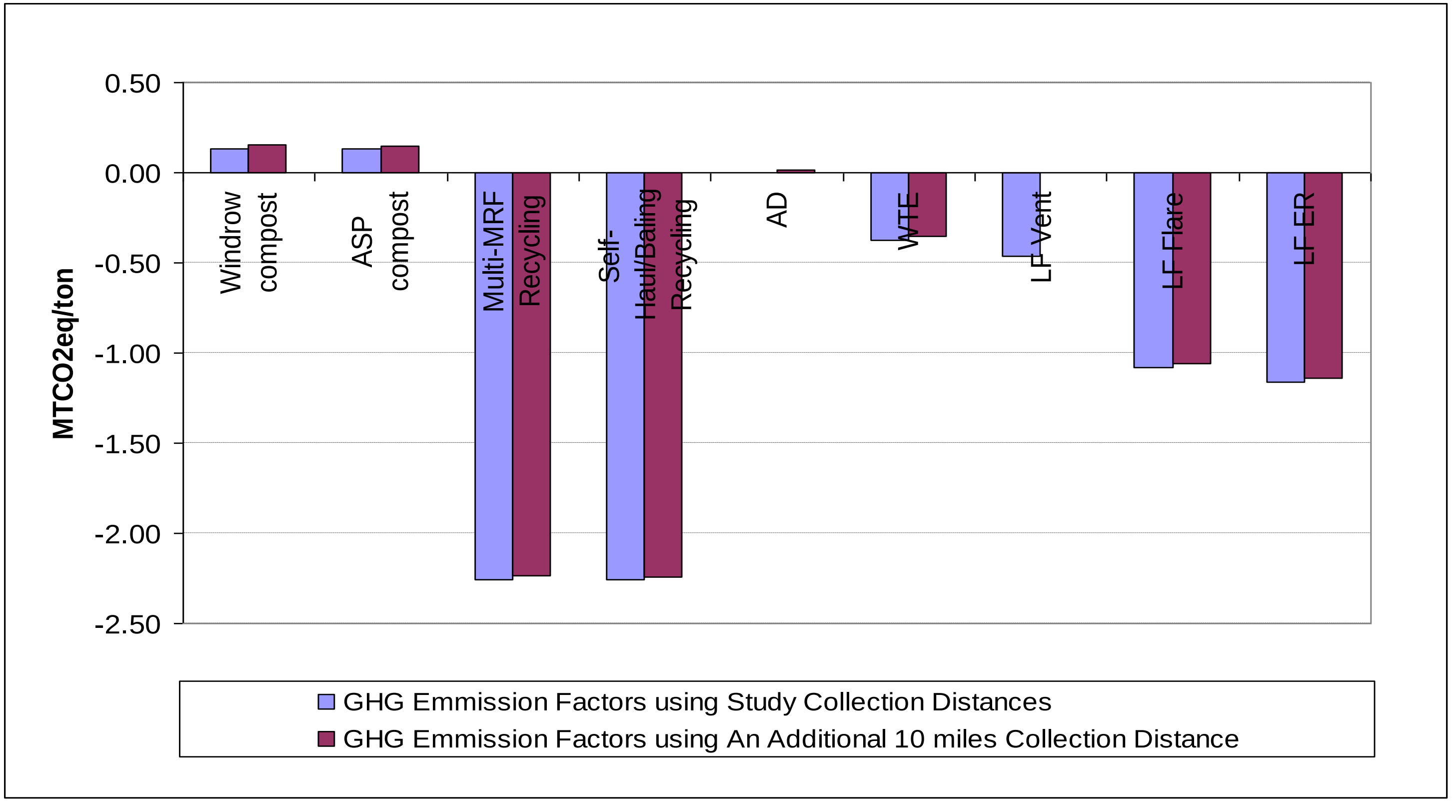

Figure 6.6. GHG Emission Factors for Newspaper Using Different Collection Distances

Sensitivity of Collection Distance

To comply with accessibility requirements, this slide has been added to the original presentation to describe the graphic on the previous slide.

Figure 6.6. GHG Emission Factors for Newspaper Using Different Product Distances

Sensitivity to changes in transportation distances was developed to evaluate changes in the GHG factors resulting from changes in the transportation distances. A 10 mile transportation distance was chosen to evaluate the changes in the emissions from the distances defined for the different scenarios evaluated in this study.

According to Figure 6.6, the ranking of the emission factors across different waste management processes is not expected to change with an additional 10 miles in the collection distances and these distances will have to change dramatically to cause a change in the ranking. In general, the changes observed are expected to be similar (in trend) for all the waste categories

With an estimated overall change in emission savings for the “Least Cost while Achieving Emission Targets” scenario, we observed an overall 0.6% increase in GHG emission savings with an additional 10 miles in collection distance, which is explained by the larger impact in the baseline emissions when compared to the impact on the scenario’s emissions.

Sensitivity of Recyclables Transportation Distance [to a Manufacturing Facility]

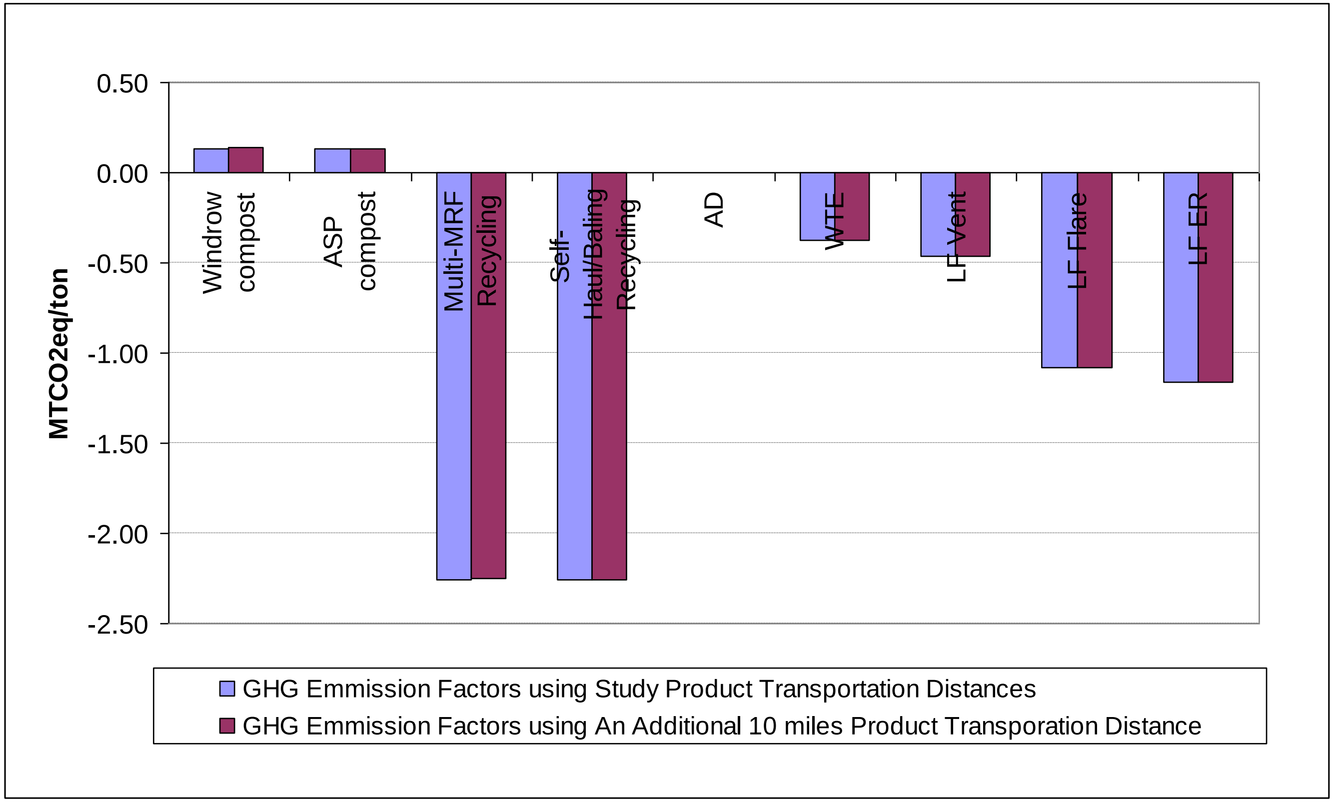

Figure 6.7. GHG Emission Factors for Newspaper Using Different Product Transportation Distances

Sensitivity of Recyclables Transportation Distance [to a Manufacturing Facility]

To comply with accessibility requirements, this slide has been added to the original presentation to describe the graphic on the previous slide.

Figure 6.7. GHG Emission Factors for Newspaper Using Different Product Transportation Distances

Sensitivity to changes in product transportation distances was developed to evaluate changes in the GHG factors resulting from changes in the transportation distances. According to Figure 6.7 the ranking of the emission factors across different waste management processes is not expected to change with an additional 10 miles in the product transportation distances and these distances will have to change dramatically to cause a change in the ranking.

The largest change in GHG emission factors as a result of changes in the product transportation distance is observed for chipping and grinding, where the product transportation plays a larger role in the overall emission factor. On the other hand, compost product transportation is not as significant in AD, which exhibits the smallest change. The product transportation distances for recycling are large enough that a 10 miles change does not make much of a difference.

With an estimated overall change in emission savings for the “Least Cost while Achieving Emission Targets” scenario, we observed an overall 0.1% decrease in GHG emission savings with an additional 10 miles in product transportation distance.

Sensitivity of Low Carbon Fuel Standard

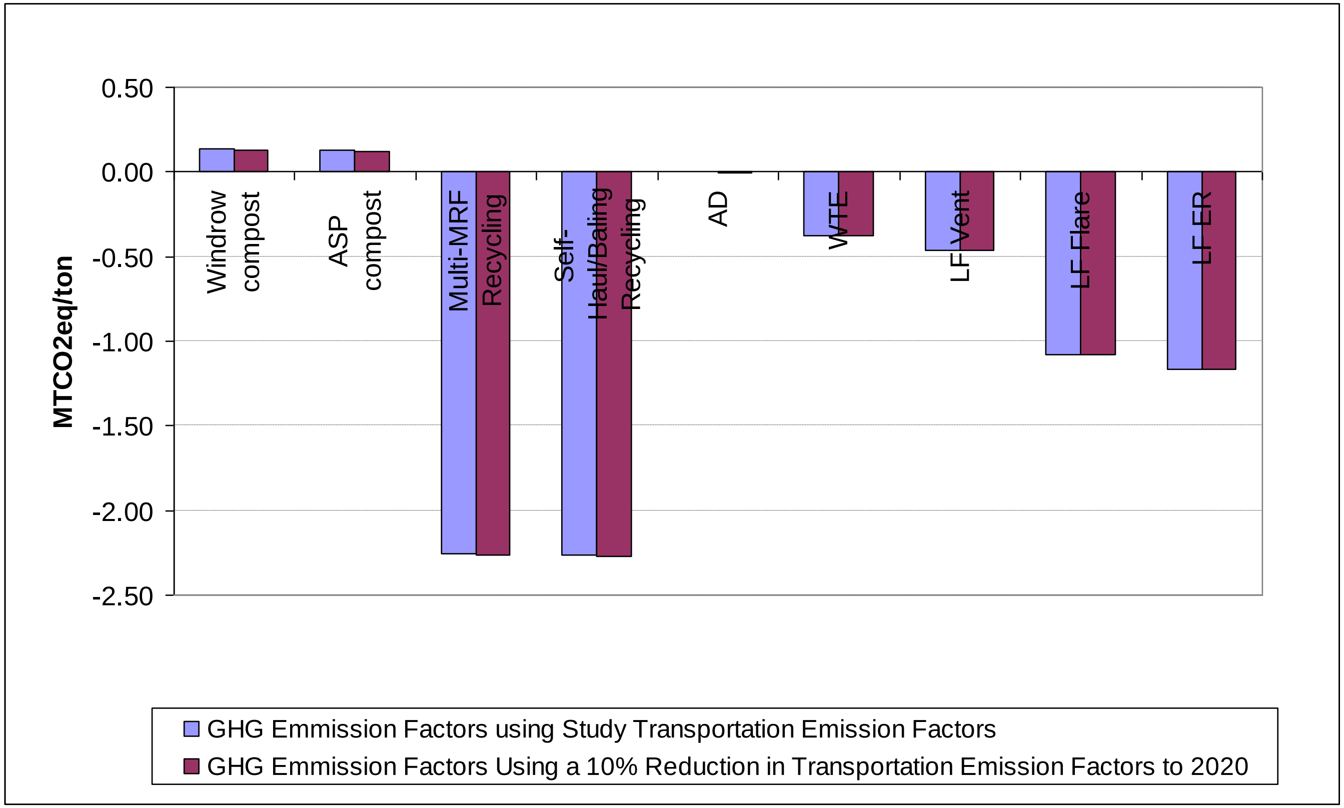

Figure 6.9. GHG Emission Factors for Newspaper Prior and After Implementation of the Low Carbon Fuel Standard

Sensitivity of Low Carbon Fuel Standard

To comply with accessibility requirements, this slide has been added to the original presentation to describe the graphic on the previous slide.

Figure 6.7. GHG Emission Factors for Newspaper Prior and After implementation of the Low Carbon Fuel Standard

Sensitivity to changes in transportation GHG emissions as a result of low carbon fuel standards was developed to evaluate changes in the GHG factors resulting from the implementation of CA Low Carbon Fuel Standard.

According to Figure 6.9 the ranking of the emission factors across different waste management processes is not expected to alter the results due to the implementation of the Low Carbon Fuel Standard. The largest change in GHG emission factors due to the implementation of the Low Carbon Fuel Standard as assumed in this analysis is observed for recycling, whose product transportation distances are particularly large and include transportation to foreign markets. In general, the changes observed are expected to be similar (in trend) for all the waste categories.

With an estimated overall change in emission savings for the “Least Cost while Achieving Emission Targets” scenario, we observed an overall 1.4% decrease in GHG emissions due to the Low Carbon Fuel Standard.

Key LCA Issues

- Science for quantifying carbon storage/sequestration is still being refined and the protocol for including or excluding in an LCA is still being debated:
  - Landfill
  - Forest (associated with paper recycling)
  - Soil (associated with compost application)
- LCA doesn't distinguish between local, regional, and global emissions.
  - Different scope and boundaries from a GHG inventory and VER-type applications
  - Energy/Emissions associated with foreign remanufacturing operations?
- LCA doesn't consider other decision making aspects:
  - Technical feasibility of alternatives
  - Sitting and permitting new facilities
  - Public perception
  - Values (e.g., conservation of materials)

Key Issue: Recycling in China

Old paper plant

New Paper Plant

Seven Dragons paper factory

How is paper recycled in Asia?
What is the benefit as compared to North American operations?

Next Steps

- Refine algorithms and factors.
- Finalize statewide and regional default data and assumptions.
- Investigate option of turning life cycle stages and/or factors (e.g., carbon storage) on and off.
- Address criteria pollutants?